NORTH COAST INTEGRATED REGIONAL WATER MANAGEMENT PLAN

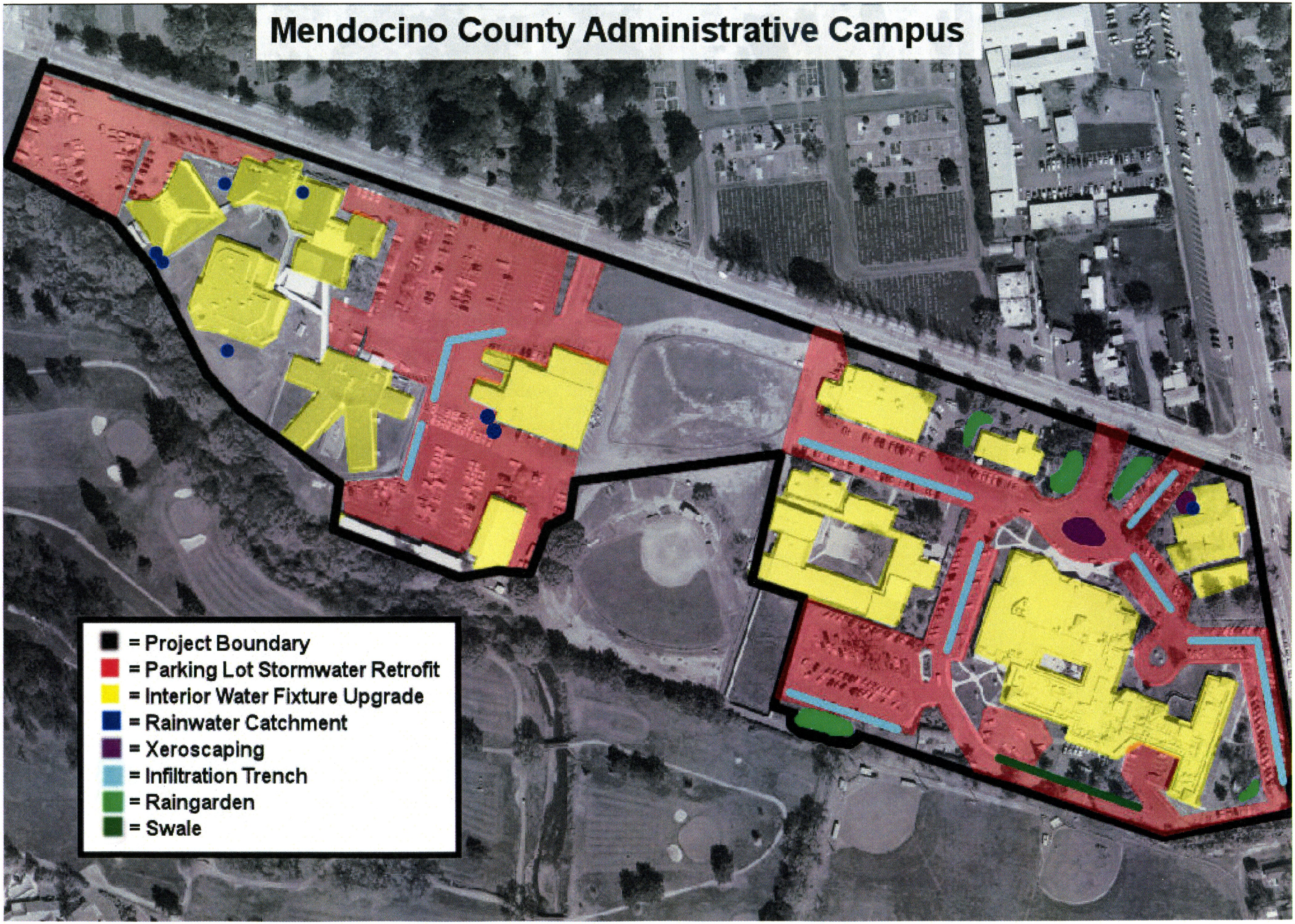
North Coast Integrated Regional Water Management Plan
Proposition 84 Round 1 Implementation Grant

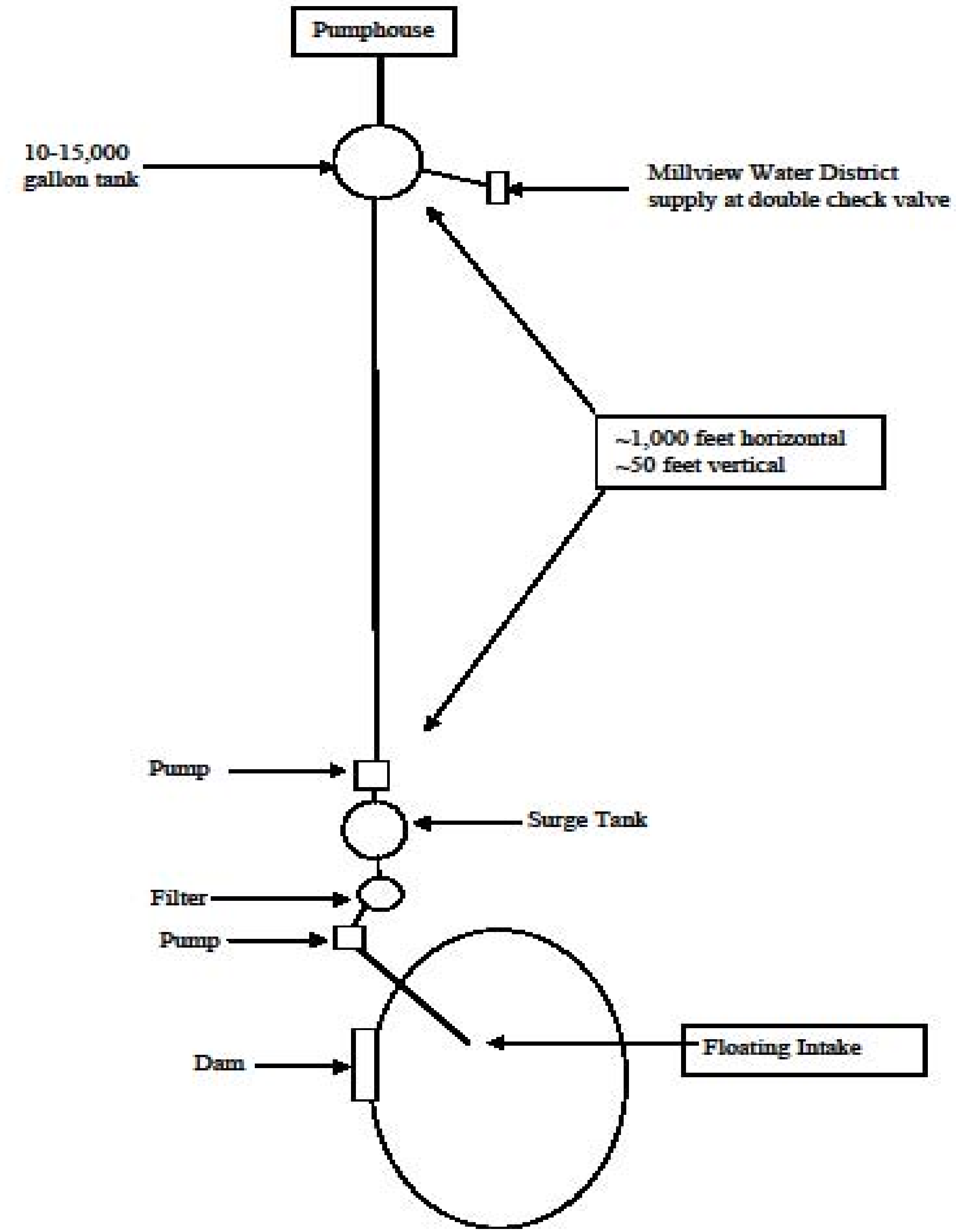
Priority Project Technical Documents: Plans and Specifications

364 - Mendocino Jumpstart Integrated Water Plan, Mendocino County Water Agency/ Planning Department

- Mendocino College Sports Fields Irrigation Recycling Project, Conceptual Diagram
- Conceptual Site Plan: College Campus
- Conceptual Site Plan: Mendocino County Campus
- California Stormwater BMP Handbook: Constructed Wetlands
- U.S. Fish and Wildlife Service. Vernal Pool Construction Monitoring Protocol and Habitat Replacement Evaluation

Mendocino College Campus


Mendocino County Administrative Campus
= Project Boundary
= Parking Lot Stormwater Retrofit
= Interior Water Fixture Upgrade
= Rainwater Catchment
= Xeroscaping
= Infiltration Trench
= Raingarden
= Swale



Mendocino Jumpstart Integrated Water Plan

Mendocino College Sports Fields Irrigation Recycling Project

Conceptual Diagram

Not To Scale

WEST COAST WATERSHED

U.S. Fish and Wildlife Service, Sacramento, CA 95825

June M. De Weese

ABSTRACT.

The Sacramento Field Office of the U.S. Fish and Wildlife Service evaluated 1,543 vernal pools constructed in Placer, Sacramento, and Butte counties between 1988 and 1994, as compensatory mitigation for 25 projects permitted by the U.S. Army Corps of Engineers, Sacramento District, to determine if existing monitor regimes were adequately assessing the target physical and biological properties of federally listed species habitat. Site specific monitoring protocol and performance standards were compared with the draft Vernal Pool Mitigation and Monitoring Guidelines and on-site evaluations were made between March 29, 1994, and April 25, 1996. The most frequently monitored element (24 sites) was the number of vernal pool endemic plant species/pool. Sixteen sites considered federally listed invertebrates and 12 reported their presence in constructed pools. Two sites relocated a federally listed plant community. Each element monitored had a wide range of performance standards with the greatest number of alternatives (16) for vernal pool endemics. Ninety-six percent of the pools met hydrology standards and 69 percent met vegetation standards. Eighty-three percent of the sites met permit compliance. Although 69 percent monitored reference pools, the performance standards between reference and constructed pools did not appear to be site specifically interdependent. In many cases, specific criterion were imposed by impact site conditions that could not be replicated at the mitigation site. Fewer variations in monitoring protocol and performance standards should be accepted for permit compliance.

INTRODUCTION

The Sacramento Field Office (SFO) of the U.S. Fish and Wildlife Service (Service) concluded in their first mitigation follow-up study that constructed wetlands which met performance standards and permit compliance often did not result in optimum habitat replacement values (DeWeese, 1994). Constructed vernal pools received the lowest replacement value ratings in that study. The Service suspected that performance standards for vernal pools were too minimal to assure successful habitat replacement. However, we had not gathered sufficient information to substantiate our concerns.

In January, 1994, an interagency team (Environmental Protection Agency, U.S. Army Corps of Engineers, California Department of Fish and Game, and the Service) was assembled to create the draft Vernal Pool Mitigation and Monitoring Guidelines (Guidelines) (Army, 1994) to assist permit applicants establish a monitoring regime that would adequately assess target physical and biological properties of constructed vernal pools. The Guidelines were peer reviewed by the academic and professional community, presented in public forum prior to distribution (Army, 1994), and released October 4, 1994, with proviso that they would be re-evaluated after one-year of field testing.

In this second mitigation follow-up study, the Service evaluated 25 vernal pool mitigation sites to determine if existing performance standards were too minimal and to assist the interagency team re-evaluate the Guidelines. Conclusions in this document are opinions of the Service and do not represent a consensus of the interagency team.

We analyzed site-specific monitoring protocol, compared existing protocol with the Guidelines, and examined the relationship between monitoring elements, performance standards and habitat replacement evaluation. We found that no field testing of the exact Guidelines protocol has been completed, however, many of the recommended elements are being monitored with a modified protocol. Only 3 sites were using the same performance standards for permit compliance. In spite of numerous variations in the site specific performance standards, a certain percentage of pools had difficulty meeting a performance standard(s) each year. Often performance standards based upon conditions at the impact site could not be duplicated at the off-site mitigation, because baseline surveys were completed in a single season and performance was based upon static criteria. The 5 sites that had on-site avoided pools to monitor as reference pools, and established reference pool-based performance standards, had the highest performance ratings and met permit compliance by year 5. However, the constructed pools at those same sites had harsh geometric shapes with steep, chronically unvegetated side slopes, and were excavated to great depths to reach a water restricting layer.

We concluded that constructed vernal pools did not have minimal performance standards, however, there were too many variations in site-specific performance standards. There should be fewer variations in monitoring protocol and performance standards to facilitate more accurate performance comparisons and assess common problems or improvements in habitat replacement.

METHODS

We selected 25 of 50 records in our mitigation follow-up study database which had impacts to vernal pools with compensatory mitigation requirements and were permitted by the Sacramento Corps District, using the following criteria: 1) the project needed to be an in-kind replacement (not replacing vernal pools with some other type of wetland), 2) at least one annual monitoring report needed to be on file (70% of the 50 records had reports on file), and 3) the total number of sites selected needed to reflect a maximum range in constructed pool age. Twelve of the 25 projects impacted more than one wetland type and required that we separate the information on constructed vernal pools from the total mitigation requirements. We reviewed all of the monitoring reports in the selected project files. To analyze the data, we created a form listing the thirteen Guidelines monitoring elements and recorded the site-specific monitoring protocol and performance standards opposite each element on a separate form for each project. The elements were: Site Selection and Construction Techniques (1), Reference Pools (2), Hydrology (3-5), Vegetation (6-9), Wildlife (10), Invertebrates (including the presence or absence of federally listed species) (11), Water Quality (12) and Site Maintenance (13).

We conducted on-site evaluations between March 29, 1994, and April 25, 1996, to observe monitoring protocol and compare performance standards with permit compliance and replacement values. We recorded the number of pools meeting site-specific performance standards and, if problems were identified, which standard was not met. Ten sites were evaluated twice to observe periods of inundation and dessication (Zedler, 1987). During our evaluations, we discovered that one project constructed pools at two different sites, had two different consultants, used two distinct monitoring regimes, therefore the results reflect 26 sites, rather than 25 projects. Each site visit was conducted with the project consultant present, to answer questions and provide us with additional specific information that may not have been discussed in the monitoring reports. The author of this study also observed construction activities and monitored pools at some sites to further evaluate specific protocol.

Additional items we investigated were: number of wetted acres constructed; number of pools impacted versus number of pools constructed; if the mitigation was on- or off-site; gross acres of preserve site; wetland density at the preserve site after implementation; and whether the preserve constructed only vernal pools or multiple wetland types.

RESULTS

Only five percent of the projects we evaluated had constructed pools the same year as the impacts. Forty-four percent of the projects had two years or more lapse between project impacts and implementing the mitigation. Seventeen sites (144.7 constructed vernal pool acres) were in Sacramento County, 8 sites (49.3 constructed vernal pool acres) were in Placer County, and 1 site (6 constructed vernal pool acres) was in Butte County. Sixty-four percent (16) of the projects implemented mitigation off-site; 36 percent (9) of the projects implemented the mitigation on-site. The combined projects constructed 1,543 vernal pools, or approximately 200 wetted acres. The greatest number of pools were constructed in 1994 (472).

Pool construction and subsequent monitoring reports were the product of 11 different consulting firms, however, one of the consulting firms monitored 11 of the 26 sites. The element most frequently monitored (24 sites) was the number of Vernal Pool Endemic (VPE) plant species/pool (Ikeda, 1990). The element least frequently monitored (0 sites) was site maintenance. Two sites had additional monitoring requirements for a special status plant population, Butte County Meadowfoam (Limnanthes floccosa ssp. californica) and Boggs Lake Hedgehyssop (Gratiola heterosepala). To facilitate comparison, the following results for specific monitoring elements include paraphrased recommendations from the Guidelines in italics.

Site Selection

Give priority to sites that historically supported vernal pools or have appropriate soil type (preferably same series as impact site) and will be adequately buffered (Castelle, 1994). Preserve sizes ranged between a minimum of 4.5 gross acres and a maximum of 520 gross acres, with the mode (6 sites) between 25 and 50 gross acres and 8 sites greater than 100 gross acres. Nineteen had constructed more than one type of wetland and many included restoration measures for existing wetlands at the mitigation site. Five sites included an intermittent stream traversing the mitigation site. Seven sites had exclusively constructed vernal pools. Thirteen projects (52%) constructed their compensatory wetlands at an off-site mitigation area which was shared with mitigation requirements for other permits, but was not an official mitigation bank. One site was an established, interagency approved, mitigation bank. Eight sites constructed vernal pools within existing vernal pool complexes, converting a low density complex into a high density complex. Three sites were constructed on former rice farms. Twelve of the mitigation sites were created in locations undesirable for wildlife habitat. For example, two sites were within utility easements with pools constructed underneath high voltage power lines, five sites were adjacent to freeways, and five sites were created on parcels that are less than 13 gross acres, surrounded by development, and inadequately buffered.

Construction Techniques

Excavate side slopes and pool bottoms that mimic impact site pools, to duplicate hydrologic depth, surface area, and inundation period. The earlier constructed pools used slope ratios of 3:1 and 4:1 and excavated to a maximum depth of 13 to 18 inches. Recently constructed pools, have slope ratios between 7:1 and 10:1, with maximum depths as shallow as 4 to 6 inches. Constructed pools at several sites were inundated for longer periods than natural pools, especially during the first two years after construction when soils may remain densely compacted. Final site density should not exceed 30 percent. The sites we evaluated had densities which ranged between 3 percent and 26 percent, pool acres to gross site acres, without consideration of other wetland types on-site. When all on-site wetland types were considered, the highest density was 44 percent after construction. Inoculum should not be stored for more than one year, to avoid adverse effects to the establishment of vegetation (Leck, 1989). Only five percent of the projects we evaluated had installed inoculum within the same year collected. Often the inoculum for both vernal pools and seasonal swales are collected and stored together. One site collected inoculum from pools on a volcanic substrate and installed the rocky-strewn soils on claypan. One of the projects constructed half of the pools one year, and stored the remaining inoculum for an additional year. The differences in plant vigor and absolute cover between the two halves were readily apparent. The pools inoculated with the longer stored soil performed poorly during the first three years of monitoring (Sugnet, 1993). Excavation spoils should be hauled off-site. Eight sites had not hauled off spoils.

Reference Pools

The establishment of biological viability can only be verified by comparing constructed pools with natural vernal pools from the same immediate area. Eighteen sites were monitoring reference pools. Five projects were monitoring avoided reference pools at the impact site. Nine projects were monitoring reference pools at the mitigation site. Four projects were monitoring reference pools somewhere within the immediate area. Seven projects did not monitor any reference pools.

Hydrology

Install two staff gauges (one deep, one shallow, where 70% pool bottom is lower) in all created and reference pools, monitor weekly at wet season. Document depth, area, and duration of inundation results with hydrographs, photographs, and aerial photography. One site had installed two gauges per pool. Seven sites had placed single staff gauges in the deepest part of the reference and constructed pools. Three sites included aerial photographs in the monitoring reports and two sites included photo-documentation of hydrology in sample pools. Five sites included hydrographs in their monitoring reports. Three sites set up a condition that hydrology be monitored for 1 year prior to installing the inoculum.

Vegetation

Measure absolute cover and relative cover (Barbour, 1987) using transects with point intercept, square meter quadrats, photo documentation and graphing; identify species with 20 percent relative cover or greater; indicate status and relative cover of hydrophytics (Reed, 1988); and determine vernal pool endemic species/pool (VPEs). Twenty-one sites monitored absolute cover, 12 sites monitored relative cover, 24 sites monitored VPEs, and 13 monitored dominance of wetland species. Most sites used visual estimates to measure absolute and relative covers. Four sites used permanent transects and 2 sites a square meter quadrat. Eleven sites included graphs depicting relative and absolute cover for each pool in their monitoring reports. Four sites included photodocumentation of vegetative cover in sampled pools. The VPE measurement was completed by identifying maximum species per pool, with the aid of a checklist of species most frequently encountered in vernal pools, indicating whether native, non-native, wetland, upland, and tallying VPEs. Fifteen sites documented a specific number of VPEs to meet permit compliance. Five sites stated VPEs had to be a specific percentage of the reference pool species. Five sites measured VPEs with a Vernal Pool Floristic Index (Sugnet, 1991).

Wildlife and Listed Invertebrates

Monitor on a case by case basis. Three sites noted all wildlife and 10 sites monitored birds. Twelve of 16 sites monitoring for invertebrates found federally listed species, either vernal pool tadpole shrimp (Lepidurus packardi) or vernal pool fairy shrimp (Branchinecta lynchi) present in constructed pools. One site found listed species in 23 of 25 constructed pools in year three. One five-year old site has found tadpole shrimp in some of their constructed pools every year.

Water Quality

Monitor on a case by case basis. Eight sites monitored temperature, turbidity, and conductivity.

Site Maintenance

Monitor for uncontrolled human disturbance, i.e., all terrain vehicles (ATVs), trash, and other unexpected conditions, i.e., soil piping, erosion, water run-off pollutants, wildlife mortality. No monitoring reports reviewed included a discussion of routine site maintenance. Three reports mentioned specific impacts (one site suffered arson, two sites photodocumented ATV damaged pools).

Performance Standards

The Guidelines performance standards are based upon establishing a reference site and primarily consider hydrology and vegetation. The performance standards for hydrology are: maximum depth of inundation within range of reference pools and longest period of inundation not greater than 125% of reference pools. The performance standards for vegetation are: absolute cover and relative cover by VPEs in each constructed pool shall be no less than the minimum recorded in the reference pools; each constructed pool must support no fewer than the lowest number of VPEs recorded in reference pools; VPEs shared by both the impact and reference pools shall be as vigorous and reproductively active in the constructed pools as the reference pools; and, by the last year of monitoring, any VPEs that are dominant (relative cover of a least 20%) in at least 30% of the reference pools shall be present as a dominant species in the constructed pools. Only 3 sites were using the same performance standards for permit compliance. Each element monitored had a wide range of performance standards with the greatest number of alternatives (16) relating to species diversity (VPEs). The most frequently shared performance standard was for avian surveys (11 sites). Table 1 lists the most frequently used site-specific performance standard for each element monitored and number of alternative standards being used at other sites. All three hydrology elements had high performance ratings: depth of inundation (96%), period of inundation (91%), and area of inundation (94%). For vegetation, 66% of the sites met the absolute cover criterion, 78% met the relative cover criterion, 89% met the species diversity criterion, and 77% met the hydrophytic criterion. Four (50%) of the 8 sites which required an invertebrate performance criterion met permit compliance.

DISCUSSION

Performance Standards Two important trends were discovered when the number of constructed pools meeting site-specific performance standards were compared with the total number of pools constructed per year: 1) pools constructed between 1988 and 1990 had the highest performance ratings and 2) in spite of numerous variations, a certain percentage of pools each year had difficulty meeting their performance standards. Six projects were constructed between 1988 and 1990. All of the projects were five or more years old and expected to fully meet performance standards on the fifth monitoring year. Five of the 6 sites monitored reference pools and stated reference pool-based performance standards between reference and constructed pools. Four sites stated the hydrology performance standard as "within range of the reference pools". The vegetation performance standards did not appear to be as site-specifically interdependent with reference pools. For example, two sites stated 7 species/pool and one site stated 12 species/pool, but did not state whether this number was an average, the minimum, or based upon a single year at the reference site. In addition, there should be no absolute or static numbers if monitoring at the reference site for comparison is every year. One project stated constructed pools should have 75% VPE relative cover, however, average reference pool absolute cover was not stated and no absolute cover was required for constructed pools. Therefore, if a pool with 80% bare ground had 75% VPE relative cover, it would pass the performance standard. Four sites required a specific percentage of absolute cover presumably based upon reference pool data, but variations over time were not documented.

In some cases, specific criterion were imposed by impact site conditions that could not be replicated at the mitigation site. Four of the 6 projects between 1988 and 1990 monitored reference pools at on-site preserves to compare with off-site constructed pools. The worst performance rating (50% pools not meeting performance standards) among this group of pools was at a site with standards based upon information gathered at the impact site over a single season. The project's vegetation standards were based upon each pool achieving 80% VPEs found in the inoculum-source pools. Surveys completed at the project site found numbers as high as 46 species per pool, because source pools had been grazed solely by horses, resulting in much richer flora than pools grazed by cattle (Balance, 1994). The constructed pools easily met the standards of the Guidelines and had a higher species diversity than existing pools at the mitigation site, yet, were not meeting permit compliance.

The earliest constructed pools in our study (1987) had poor performance in hydrology. The crucial element for vernal pool construction is the presence of a vernal pool forming soil, which includes the presence of a water restrictive layer (Stromberg, 1994). The Guidelines recommend that site selection include historic vernal pool soils to ensure success. Vernal pools constructed on historic vernal pool soils could equally be considered restoration. Table 2 lists the total number of pools constructed and how many failed (either or both) the hydrology or vegetation standards each year. The figures indicate that no pools have failed hydrology since 1991. This clearly indicates that more pools are being constructed on the proper soils. As of November 13, 1992, it has been the policy of the Sacramento Corps District not to authorize the use of bentonite linings to create wetlands, including vernal pools, because subsequent impacts, i.e., cattle, ATVs, could cause the bentonite to suspend in the water column (Norton, K., pers. comm.) and damage to the liner would drain the pool and prevent further ponding.

Pools constructed in 1994 had the lowest performance ratings (60% pools failing a performance standard). Further examination revealed that 125 pools at one site had required hydrology monitoring for one year prior to inoculation, and hence, were not yet meeting the vegetation standard. At another site, 155 pools were not meeting the 80% absolute cover standard because the site was only one year old. Neither site needed remediation, because both were on track to meet performance standards by year five. The average percent of pools constructed between 1987 and 1994 that needed remediation was 35%.

Habitat Replacement Evaluation

Vernal pool mitigation sites are selected and constructed based on economy of scale and density to get the greatest wetland acreage within the smallest land area. The impact site is typically comprised of uplands, seasonal wetlands, vernal pools, interconnecting swales, and perhaps an ephemeral stream. The average vernal pool compensation is a fragmented replacement, resulting in a potential loss of functions. Compensation vernal pools are often separated from other mitigation components and homogeneously combined with additional projects. Because swales are not easily re-created, additional isolated depressions are excavated at the vernal pool site to create seasonal wetlands as compensation for the swale acreage.

Constructing fewer and larger pools is more cost effective than a direct replication of the impact site (Francisco, R., 1994), hence, most of the projects impacted a greater number of pools than were constructed at the mitigation site. In addition, we did not observe any concerted effort to create microtopographic pool bottoms for enhancing plant distribution and invertebrate habitat in the constructed pools we evaluated. The resulting change in hydrologic regime on the transplanted vegetation is readily apparent when compared over a five-year period. The first two years, there is comparible diversity and most of the plant species captured in the inoculum appear. Starting in the third year and sometimes sooner, it appears that a shift in species cover class (Braun-Blanquet In Barbour, 1987) occurs, with the floristics which prefer longer inundation i.e., Eleocharis macrostachya, beginning to dominate. These conclusions are based upon our observations of the same mitigation sites over time and comparing five years of cover class detailed in the monitoring reports. However, to fully determine what plant species may be significantly reducing in number, due to lack of adaptation to the re-created habitat, would require additional extensive research.

One consultant stated that the 2:1 mitigation ratio reduced available inoculum by one-half and resulted in sparce cover during the first three years (Whitney, K., 1994). However, the sites we evaluated had a variable replacement ratio, usually lower than 2:1. For projects implemented after September 1, 1995, the Service added a preservation component which reduces the creation ratio to 1:1, if the impacted vernal pools also are habitat for listed species. We hope to see a more rapid establishment of vegetation with this reduced ratio, and will be tracking the results.

The steep slopes of early constructed pools were the subject of vigorous criticism, because of their unnatural appearance, and the resulting "bathtub ring" due to vegetation not establishing on the slopes. The steep slopes also did not provide optimum habitat for shorebirds and migratory waterfowl (Recher, 1966). More recent constructed pools have gentle slopes that are not only more aesthetically pleasing, but also are less likely to have unvegetated slopes. To further prevent bare slopes, many of the consultants "double seed" slopes by raking some upland topsoils downward towards pool bottoms and some inoculum upwards, overlapping the soils on pool slopes. Pools shapes are randomly designed and, over time, have evolved from harsh geometrics to shapes which more accurately mimic nature.

Routine site maintenance needs to have a higher priority and discussed in monitoring reports. The adverse impacts most frequently observed were trash dumping, ATV ruts, and uncontrolled weeds. Often invasive non-native plant species readily adapt to the recently disturbed sites and contribute to increased fire hazards. Some of the consultants have attempted weed control by hydroseeding pool perimeters immediately after construction. Routine maintenance, such as mowing or hand weeding, is labor intensive and often ignored. Most mitigation sites are too close to urban development for controlled burns and generally, we do not recommend the use of pesticides or herbacides within vernal pool habitats. One of the sites requested managed grazing to keep weeds under control and recently received approval from the Corps and the Service.

Numerous passerines, shorebirds, waterfowl, and jackrabbits are attracted to the compensatory wetlands we evaluated, regardless of whether they exactly replicate vernal pools. We observed 15 different wildlife species at one of the mitigation sites, including members of various levels in the food chain, culminating with a coyote. One of the potential problems we have noticed with constructed pools is that they often do not exhibit small mammal burrowing or deep hydric cracks in pool bottoms the first and second years, presumably because the soil remains densely compacted and soil ped formation has not occurred. These conditions could potentially delay establishment of species that utilize burrows and cracks for estivation habitat, such as tiger salamanders and spadefoot toads. Small mammal burrowing also creates additional microtopography which enhances the pool habitat for plants and invertebrates.

The art and science of constructing vernal pools has greatly improved over the past eight years. The technology for constructing wetlands that will provide viable habitat for rare plant populations, federally listed invertebrates, migratory waterfowl, and other wildlife will continue to improve if we can specifically document what has been successful and what has failed. Our study concluded that, if we are to enable valid performance comparisons over time, fewer variations in monitoring protocol and performance standards should be accepted for permit compliance.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Sacramento Corps District personnel and the private consultants who granted access to the mitigation sites and fully cooperated with our investigations; the original interagency team members who wrote the Guidelines: Tom Cavanaugh (Corps), June DeWeese (Service), Julie Horenstein (CDFG), Paul Jones (EPA), Mark Littlefield (Service); and Brian Cordone (Service), who completed seven of the site evaluations. This study was partially funded by EPA, Region 9 Water Management Division, San Francisco, CA.

LITERATURE CITED

Army Corps of Engineers, Sacramento District. 1994. (Draft) Appendix A. Specific habitat mitigation and monitoring guidelines for vernal pools. Army Corps of Engineers. Sacramento, CA.

_____. 1994. Comments received on draft specific habitat mitigation and monitoring guidelines for vernal pools (prior to and after the vernal pool forum of April 20, 1994). Army Corps of Engineers. Sacramento, CA. .

Balance Hydrologics, Inc. 1994, 95, 96. Power's house wetland mitigation project, third (1994), fourth (1995), fifth (1996) year monitoring reports, Balance Hydrologics, Inc. Berkeley, CA.

Barbour, M. 1987. Terrestrial plant ecology. The Benjamin/Cummings Publishing Co., Inc. Menlo Park, CA. 634 pp.

Castelle, A. 1994. Wetland and stream buffer size requirements - a review. Journal of Environmental Quality, 1994 Sep-Oct, V23 N5:878-882.

Davis2. 1994, 95. Lexington Hills offsite wetlands mitigation at apple road, monitoring plan and reports for first and second years (1994), third year (1995). Davis2. Georgetown, CA.

DeWeese, J. 1994. An evaluation of selected wetland creation projects authorized through the Corps of Engineers section 404 program. Sacramento, CA. U.S. Fish & Wildlife Service.

Francisco, R. Field Design Specialist. Jones & Stokes Associates. Sacramento, CA. Meeting - September 26, 1994. Churchill Downs project evaluation, Year 0.

Gibson & Skordal. 1993, 95. Eastridge project first (1993), second (1995) growing season, mitigation monitoring report. Gibson & Skordal. Sacramento, CA. .

_____. 1993, 95. Perry Ranch/Fallbrook project, first (1993) third (1995) year mitigation monitoring report. Gibson & Skordal. Sacramento, CA.

_____ . 1995. Sun City Roseville 1995 growing season, mitigation monitoring report. Gibson & Skordal. Sacramento, CA.

Huffmann, T. 1994. Wetland mitigation monitoring report for the 1993 growing season, Stanford ranch property. Huffmann & Associates. Larkspur, CA.

Ikeda, D. 1990. Vernal Pool Plants, their habitat and biology. California State University, Chico, CA. 179 pp.

Jones & Stokes. 1992. The Parkway at Blue Ravine: parkway and resource mitigation plan. Jones & Stokes. Sacramento, CA.

Kelley, D. 1992. Farm Credit project, Butte county meadowfoam final mitigation plan. Kelley & Associates. Davis, CA.

Leck, M. 1989. Wetland seed banks In Ecology of soil seed banks. Rider College. Lawrenceville, N.J. 283 - 298 pp.

LSA Associates, Inc. 1990. Conceptual wetland mitigation plan Sheldon North subdivision. LSA Associates, Inc. Point Richmond, CA

Norton, K. Ecologist/Permit Manager. Army Corps of Engineers, Sacramento District, Regulatory

Branch, Central CA and NV Secion, San Joaquin Valley Office.

Sacramento, CA. Telephone conversation of May 2, 1996.

Recher, H. 1966. Some aspects of the ecology of migrant shorebirds. University of Pennsylvania. Philadelphia, PA.

Reed, P.B., Jr. 1988. National list of plants that occur in wetlands: California (Region 0). (Biological Report 88[26.10]) US Fish and Wildlife Service. Washington, DC.

Stromberg, L. Wetlands Consultant. Laurence P. Stromberg, Ph.D. Richmond, CA. Meeting - March 30, 1994. Sun City evaluation, Year 0.

Sugnet & Associates. 1995. Broadstone Villages project, 1995 wetland mitigation monitoring report. Sugnet & Associates. Roseville, CA.

_____. 1996. Churchill Downs, 1995 wetland mitigation monitoring report. Sugnet & Associates. Roseville, CA.

_____. 1992, 93, 95, 96. Elliott Ranch, 1992, 93, 95, 96 wetland mitigation monitoring reports. Sugnet & Associates. Roseville, CA.

_____. 1993, 95, 96. Elk Grove Blvd. Extension/I-5 Interchange, 1992&93, 94, 95 wetland mitigation monitoring report. Sugnet & Associates. Roseville, CA.

_____. 1993. Olympus Pointe parcel nine 1993, wetland mitigation monitoring report. Sugnet & Associates. Roseville, CA.

_____. 1996. Roseville 150 project, 1995 wetland mitigation monitoring report. Sugnet & Associates. Roseville, CA.

_____. 1993. Sammis Sunrise-Douglas wetland preservation and compensation plan. Sugnet & Associates. Roseville, CA.

_____. 1994, 95. Silverado Oaks project, 1994, 95 wetland mitigation monitoring report. Sugnet & Associates. Roseville, CA.

_____. 1991, 95, 96. Woodcreek Oaks project, 1991, 95, 96 wetland mitigation monitoring report. Sugnet & Associates. Roseville, CA.

Swift, R. and Morgan, S. 1995. Wildlands mitigation bank, phase IA & IB constructed habitat summary. Wildlands, Inc. Roseville, CA.

Whitney, K. Principal environmental consultant. Foothill Associates. Rocklin, CA. Meeting - March 2, 1994. Elliott Ranch project evaluation, Year 2/3.

Zar, J. 1984. Biostatistical Analysis. Prentice Hall. Englewood Cliffs, N.J. 718 pp.

Zedler, P. 1987. The ecology of southern California vernal pools: a community profile. (Biological Report 85 [7.11] US Fish and Wildlife Service. Washington, DC.

Zentner, J. 1989, 90, 91, 92, 94. City of Sacramento, Laguna creek stream corridor first (1989), second (1990), third (1991), fourth (1992), and final (1994) monitoring report and performance standard review, Vols I and II. Zentner & Zentner. Walnut Creek, CA.

_______. 1992. Laguna Springs first year (1992) monitoring report. Zentner & Zentner. Walnut Creek, CA.

_______. 1994, 96. Laguna West VI wetland mitigation monitoring program, second (1994), third (1996) year report. Zentner & Zentner. Lafayette, CA. 12 pp.

_______. 1992, 93, 94, 95. Lexington Hills stream corridor second (1992), third (1993), fourth (1994), and fifth (1995) year monitoring reports, Corps portion. Zentner & Zentner. Lafayette, CA.

NORTH COAST INTEGRATED REGIONAL WATER MANAGEMENT PLAN

North Coast Integrated Regional Water Management Plan
Proposition 84 Round 1 Implementation Grant

Priority Project Technical Documents: Plans and Specifications

374 &376 - Nissa-kah Creek Fish Passage Removal, Hopland Band of Pomo Indians

- Steiner Environmental Consulting. 1996. A History of the Salmonid Decline in the Russian River. 86pp.
- Ross Taylor and Associates. 2006. Hopland Band of Pomo Indian Reservation—Stream Crossing Inventory and Fish Passage Evaluation. 53pp.
- Ross Taylor and Associates (RTA). 2008. Habitat Typing Surveys of Russian River Tributaries located on the Hopland Band of Pomo Indians Reservation. 26pp.
- Allen, Steven and Michael Love. 2009. Design Report for a Fish Passage Improvement Project on Nissa-Kah Creek at Nokomis Road. Winzler&Kelley and Michael Love & Associates, 24pp.
- Allen, Steven. Alternatives Analysis for Nissa-Kah Creek Crossing at Highway 175, Hopland, California. Winzler&Kelley. 11pp.

HOPLAND BAND OF POMO INDIAN RESERVATION
STREAM CROSSING INVENTORY AND FISH PASSAGE EVALUATION

Prepared for the Hopland Band of Pomo Indians' EPA Division

By

Ross Taylor and Associates

August, 2006

Ross Taylor and Associates
1254 Quail Run Court
McKinleyville, CA 95519
(707)-839-5022
rossntaylor@sbcglobal.net

INTRODUCTION

The inventory and fish passage evaluation of stream crossings within the Hopland Pomo Indian Reservation land was conducted between May and August of 2006. The primary objective was to assess passage of juvenile, resident, and adult coastal rainbow trout/steelhead (*Oncorhynchus mykiss*) and to identify sites that were inhibiting passage for any of the life stages.

Please note that for this report the term **stream crossing** is defined as any human-made structure, (used primarily for transportation purposes) that crosses over or through a stream channel, such as: a paved road, unpaved road, railroad track, biking or hiking trail, golf-cart path, or low-water ford. Stream crossings include culverts, bridges, and low-water crossings such as paved and unpaved fords. For the purpose of assessing fish passage, the distinction between types of stream crossings is not as important as the effect the structure has on the form and function of the stream flow. A stream crossing encompasses the structure employed to pass stream flow as well as associated fill material within the crossing prism.

The inventory and assessment process included:

1. Locating stream crossings within anadromous stream reaches.
2. Visiting each crossing on an initial site visit to determine the type of crossing and assessment of stream channel as suitable fish habitat.
3. At crossings with culverts - collecting information regarding culvert specifications and surveying a longitudinal profile. Cross section elevations were surveyed in situations where additional data aided in modeling flow and fish passage limitations.
4. Assessing fish passage using culvert specifications and passage criteria for juvenile and adult coastal rainbow trout/steelhead (*Oncorhynchus mykiss*) (state and federal criteria) by employing a first-phase evaluation filter and then using a computer software program (FishXing) for a more in-depth analysis of flow regimes and passage limitations for the various life stages.
5. Assessing (estimated) quality and quantity of stream habitat above each culvert.
6. Ranking sites using criteria developed by the California Department of Fish and Game (CDFG) and providing general recommendations for improving fish passage conditions.

Final Product of Stream Crossing Inventory

This final report includes:

1. A count and location of all stream crossings with culverts and other manmade structures located within fish-bearing stream reaches. Locations were identified by stream name; road name; watershed name; mile marker or distance to nearest named crossroad; USGS Quad name; Township, Range and Section coordinates; and lat/long coordinates (NAD27 datum). All location data were entered into a spreadsheet for potential database uses. In addition to the four site surveys conducted in May 2006, the results section of this report includes data collected on four stream crossings surveyed by Ross Taylor and Associates in 2003 during the CDFG-funded Russian River Fish Passage Inventory.

2. For each site, crossing specifications were collected, including: length, diameter, type, position relative to flow and stream gradient, amount of fill material, depth of jump pool below crossing, height of leap required to enter crossing, previous modifications (if any) to improve fish passage, and evaluate effectiveness of previous modifications. All site-specific data were entered into a spreadsheet for potential database uses.

3. Information regarding crossing age, wear, and performance was collected, including: overall condition of the crossing (and associated road fill) and rust line height (applicable only to metal culverts). All crossing specifications were entered into a spreadsheet for potential database uses.

4. An evaluation of fish passage at each crossing. Fish passage was evaluated by two methods. Initially, fish passage was assessed by employing a first-phase evaluation filter that was developed for Part IX of CDFG's *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003). The filter quickly determined if a crossing either met fish passage criteria for all species and life stages as defined by CDFG for the range of migration flows (**GREEN**); failed to meet passage criteria for all species and life stages (**RED**); or was a partial/temporal barrier (**GRAY**). Then FishXing (a computer software program) was used to conduct in-depth passage evaluations on all sites by modeling culvert hydraulics over the range of migration flows and comparing these values with leaping and swimming abilities of the species and life stages of interest

5. Digital photo documentation of each crossing was taken to provide visual information regarding inlet and outlet configurations; as well as insertion in future reports, proposals, or presentations.

6. An evaluation of the quantity and quality of fish habitat above each crossing. Habitat information was obtained from habitat typing and fisheries surveys recently conducted by CDFG as part of their assessment of Russian River tributaries. Where feasible, a first-hand inspection and evaluation of stream

habitat occurred. Lengths of potential anadromous habitat were also estimated from USGS topographic maps.

7. A ranked list of crossings that require treatment to provide unimpeded fish passage to spawning and rearing habitat. On a site-by-site basis, general recommendations for providing unimpeded fish passage were provided.

Project Justification

Fish passage through crossings (especially culverts) is an important factor in the recovery of depleted salmonid populations throughout the Pacific Northwest. Although most fish-bearing streams with culverts at stream crossings tend to be relatively small in size with only a couple of miles or less of upstream habitat, thousands of these exist and the cumulative effect of blocked habitat is probably quite significant. Recent research regarding watershed restoration considers the identification, prioritization, and treatment of migration barriers to restore ecological connectivity for salmonids a vital step towards recovering depressed populations (Roni et al. 2002).

Culverts often create temporal, partial or complete barriers for anadromous salmonids on their spawning migrations (Table 1) (adapted from Robison et al. 2000). Typical passage problems created by culverts are:

- Excessive drop at outlet (too high of entry leap required);
- Excessive velocities within culvert;
- Lack of depth within culvert;
- Excessive velocity and/or turbulence at culvert inlet; and
- Debris accumulation at culvert inlet and/or within culvert.

Table 1. Definitions of barrier types and their potential impacts.

Barrier Category	**Definition**	**Potential Impacts**
Temporal	Impassable to all fish some of the time	Delay in movement beyond the barrier for some period of time
Partial	Impassable to some fish at all times	Exclusion of certain species and life stages from portions of a watershed
Total	Impassable to all fish at all times	Exclusion of all species from portions of a watershed

Even if culverts are eventually negotiated, excess energy expended by fish may result in their death prior to spawning or reductions in viability of eggs and offspring. Migrating fish concentrated in pools and stream reaches below stream crossings are also more vulnerable to predation by a variety of avian and mammalian species, as well as poaching by humans. Culverts which impede adult passage limit the distribution of spawning, often resulting in under-seeded headwaters and superimposition of redds in lower stream reaches.

Current guidelines for new culvert installation aim to provide unimpeded passage for both adult and juvenile salmonids (CDFG 2002, NOAA 2001). However many existing culverts on federal, state, county, city, and private roads are barriers to anadromous adults, and more so to resident and juvenile salmonids whose smaller sizes significantly limit their leaping and swimming abilities to negotiate culverts. For decades, “legacy” culverts on established roads have effectively disrupted the spawning and rearing behavior of all four species of anadromous salmonids in California: Chinook salmon (*O. tshawytscha*), coho salmon, coastal rainbow trout (steelhead are anadromous coastal rainbow trout), and coastal cutthroat trout (*O. clarki clarki*).

In recent years, there has been a growing awareness of the disruption of in-stream migrations of resident and juvenile salmonids caused at road/stream intersections. In-stream movements of juvenile and resident salmonids are highly variable and still poorly understood by biologists. Juvenile coho salmon spend approximately one year in freshwater before migrating to the ocean, and juvenile steelhead may rear in freshwater for up to four years prior to out-migration (one to two years is most common in California). Thus, juveniles of both species are highly dependent on stream habitat. Many studies indicate that a common strategy for over-wintering juvenile coho salmon is to migrate out of larger river systems into smaller streams during late-fall and early-winter storms to seek refuge from possibly higher flows and potentially higher turbidity levels in mainstem channels (Skeesick 1970; Cederholm and Scarlett 1981; Tripp and McCart 1983; Tschaplinski and Hartman 1983; Scarlett and Cederholm 1984; Sandercock 1991; Nickelson et al. 1992). Recent research conducted in coastal, northern California watersheds suggests that juvenile salmonids migrate into smaller tributaries in the fall and winter to feed on eggs deposited by spawning adults as well as flesh of spawned-out adults (Roelofs, pers. comm). Direct observation at numerous culverts in northern California confirmed similar upstream movements of three year-classes of juvenile steelhead (young-of-year, 1-year old and 2-year old) (Taylor 2000; Taylor 2001). The variable life history of resident coastal rainbow trout is exhibited by seasonal movements in and out of one or more tributaries within a watershed. These smaller tributaries are where most culverts are still located since larger channels tend to be spanned by bridges.

METHODS AND MATERIALS

Methods for conducting the stream crossing inventory and fish passage evaluation included seven tasks; accomplished generally in the following order:

1. Location of stream crossings.
2. Initial site visits and data collection.
3. Estimation of tributary-specific hydrology and design flows for presumed migration period.
4. Data entry and passage analyses. Passage was first evaluated with a first-phase evaluation filter referred to as the "Green-Gray-Red" filter. Sites determined to be "Gray" and/or "Red" then required an in-depth evaluation with FishXing – a computer modeling software.
5. Collection and interpretation of habitat information for site prioritization.
6. Prioritization of sites for corrective treatment.
7. Site-specific recommendations for improving fish passage conditions.

These methods were fairly consistent with the protocol developed for Part IX of the CDFG *California Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003). These methods were developed to be consistent with current state and federal fish passage criteria for anadromous salmonids (CDFG 2002, NMFS 2001).

Location of Stream Crossings

Preliminary project scoping for stream crossings to survey included examination of USGS maps and counting road/stream intersections on known (current and historic) anadromous stream reaches. Given the relatively small geographic area encompassed within the project, each road/stream crossing within the reservation boundary was visited with the Tribal EPA coordinator to determine sites needing further data collection and analysis.

Access Permission

Because all sites were within the Hopland Pomo Tribe Reservation land boundary, no further effort to obtain access permission was required to conduct the study.

Initial Site Visits

The objective of the initial site visits was to collect physical measurements at stream crossings to utilize with the first-phase evaluation filter and with the FishXing passage evaluation software. Notes describing the type and condition of each crossing, as well as qualitative comments describing stream habitat immediately above and below each crossing were also included. Site photographs taken included: upstream and downstream sides of the crossing, locations of cross-section tape, stream channel conditions, and/or crossing condition such as damage or unique features.

Stream Crossing Type

Potential sites were visited in the field. With the exception of two ford crossings, all road/stream crossings within the study area were culverts. The fords were determined to be of no significance as potential barriers to fish migration. However, these sites could potentially be sources of excess fine sediment delivery during storm runoff. Field measurements were collected at each culvert site.

Crossing Location

The location of each stream crossing within a fish-bearing stream reach was described by: road name; stream name; watershed name; name of USGS quad map; Township, Range, and Section; latitude and longitude; and mile marker or distance to nearest named cross-road. Lat/long coordinates were determined using Terrain Navigator (Version 3.01 by MapTech™), a geo-referenced mapping software program; or in the field with a handheld GPS unit. For data entry and analyses purposes, all lat/long coordinates were provided in the North American 1927 datum (NAD27).

Longitudinal Survey

A longitudinal survey was shot at each crossing to provide accurate elevation data for FishXing passage analyses. We utilized an auto-level (Topcon™ AT-G7) with an accuracy of ± 2.5 mm, a domed-head surveyor's tripod, and a 25' leveling rod in 1/100' increments. All data and information were written on water-proof data sheets with a pencil. Data sheets were photocopied to provide back-ups in case of loss or destruction of originals.

Once a site was located in the field by the two-person survey crew, bright orange safety cones with signs marked "Survey Party" were placed to warn oncoming traffic from both directions. Bright orange vests were also worn by the survey crew to increase one's visibility to traffic.

To start the survey, a 300-foot tape (in 1/10' increments) was placed down the approximate center of the stream channel. The tape was started on the upstream side of the crossing, usually in the riffle crest of the first pool or run habitat unit above the crossing. This pool or run was considered the first available resting habitat for fish after negotiating the stream crossing.

The tape was set to follow any major changes in channel direction. The tape was set through the culvert and continued downstream to at least the riffle crest (or tail-water control) of the pool immediately downstream of the crossing outlet. If a tail-water cross-section was measured, the 300-foot tape was set past the tail-water control to measure downstream channel slope. Extreme caution was used when wading through or over the crossings. A hardhat and flashlight were standard items used during the surveys.

The tripod and mounted auto-level were set in a location to eliminate or minimize the number of turning points required to complete the survey. If possible, a location within the stream channel was selected to avoid road traffic. The leveling rod was placed at the thalweg (deepest point of channel cross-section at any given point along the center tape) at various stations along the center tape, generally capturing visually noticeable breaks in slope along the stream channel.

At all sites, a temporary benchmark (TBM) was established in order to allow someone to easily re-survey the site to either check the accuracy of our surveys or to conduct a survey prior to designing or implementing a treatment. TBM's were typically established by spray-painting an "X" on a relatively permanent feature such as a concrete wing-wall or head-wall. The locations of all TBM's were clearly marked on the site sketches.

At all sites, elevations required to run FishXing were measured (Figure 1):

1. crossing inlet,
2. crossing outlet,
3. maximum pool depth within five feet of the outlet,
4. outlet pool tail-water control,
5. a point downstream of the tail-water control, and
6. a cross-section at the tail-water control.

Each cross-section was comprised of approximately eight to 10 elevations from the left bank-full channel margin to the right bank-full margin. These cross sections allowed for more accurate modeling of changes in tail-water elevations over varying stream discharges with the FishXing software. All elevations were measured to the nearest 1/100' and entered with a corresponding station location (distance along center tape) to the nearest 1/10'.

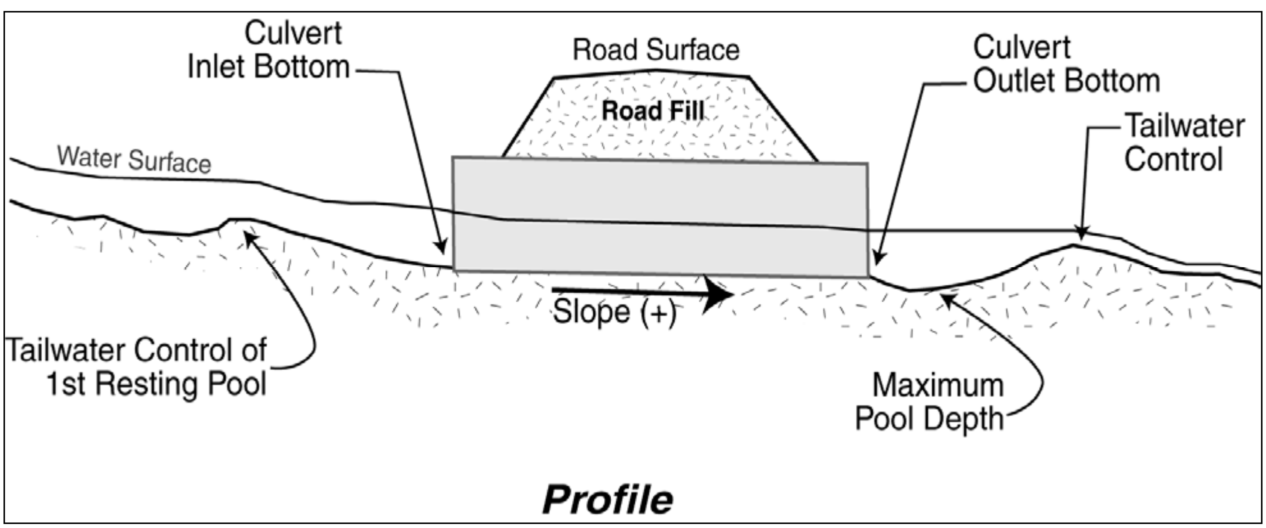


Figure 1. Diagram of required survey points though a culvert at a typical stream crossing.

On a site-specific basis, the following additional survey points provided useful information for evaluating fish passage with FishXing:

- Apparent breaks-in-slope within the crossing. Older culverts often sag when road fills slump, creating steeper sections within a culvert. If only inlet and outlet elevations are measured, the overall slope will predict average velocities less than actual velocities within steeper sections. These breaks-in-slope may act as velocity barriers, which are masked if only the overall slope of the culvert is measured. The tripod and auto-level were set within the culvert or channel to measure breaks-in-slope.

- Steep drops in the stream channel profile immediately upstream of the culvert inlet. Measure the elevation at the tail of the first upstream holding water (where the tape was set) to estimate the channel slope leading into the culvert. In some cases, a fish may negotiate the culvert only to fail at passing through a velocity chute upstream of the inlet entrance. Inlet drops often create turbulent conditions during elevated flows.

Channel Widths

Where feasible, at least five measurements of the active channel width above the crossing (visually beyond any influence the crossing may have on channel width) were taken. Active channel is defined as the portion of channel commonly wetted during and above winter base flows and is identified by a break in rooted vegetation or moss growth on rocks along stream margins. Some stream crossing design guidelines utilize active channel widths in determining the appropriate widths of new culvert installations (CDFG 2002; NMFS 2001; Robison et al 2000; Bates et al. 1999).

Fill Estimate

At each crossing, the volume of road fill placed above the stream channel was estimated from field measurements. Fill volume estimates can be incorporated into the ranking of sites for treatment and can assist in:

1. Determining potential volume of sediment deliverable to downstream habitat if the stream crossing failed.
2. Developing rough cost estimates for barrier removal by estimating equipment time required for fill removal and disposal site space needed.

Road fill volume is estimated using procedures outlined in Flannigan et al. (1998). The following measurements are taken to calculate the fill volume (Figure 2):

1. Upstream and downstream fill slope lengths (L_d and L_u).
2. Slope (%) of upstream and downstream fill slopes (S_d and S_u).
3. Width of road prism (W_r).

4. Top fill width (W_f).
5. Base fill width (W_c).

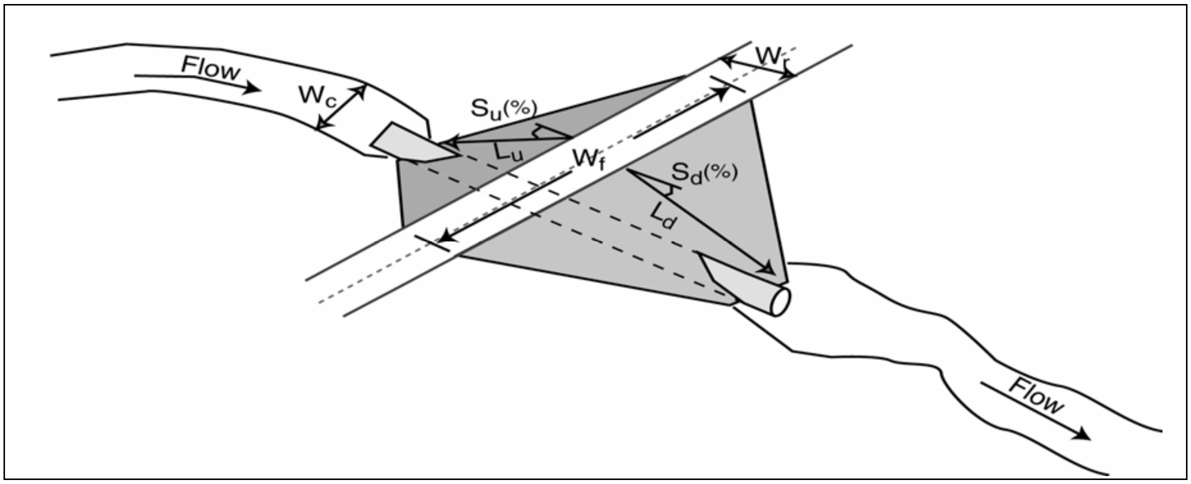


Figure 2. Road fill measurements.

Equations (1) through (4) were used calculate the fill volume.

(1) Upstream prism volume, V_u:

$$V_u = 0.25(W_f + W_c)(L_u \cos S_u)(L_u \sin S_u)$$

(2) Downstream prism volume, V_d:

$$V_d = 0.25(W_f + W_c)(L_d \cos S_d)(L_d \sin S_d)$$

(3) Volume below road surface, V_r:

$$V_r = 0.25(H_u + H_d)(W_f + W_c)\ W_r$$

where: $H_u = L_u \sin S_u$, and

$H_d = L_d \sin S_d$

(4) Total fill volume, V:

$$V = V_u + V_d + V_r$$

NOTE: The fill measurements used as part of this inventory protocol were meant to generate rough volumes for comparison between sites while minimizing the amount of time required collecting the information. These volume estimates may contain significant error and should not be used for designing replacement structures.

Other Site-specific Measurements

For each crossing with a culvert, the following specifications were collected:

1. Length (to nearest 1/10 of foot);
2. Dimensions: diameter (circular), or height and width (box culverts), or span and rise (pipe arches and open-bottom arches);
3. Type: corrugated metal pipe (CSP), structural steel plate (SSP), concrete pipe, concrete box, open-bottom pipe arch, squashed pipe-arch, or a composite of materials;
4. Overall condition of pipe (good, fair, poor, extremely poor);
5. Height and width of rustline (if present);
6. Position relative to flow and stream gradient;
7. Depth of pool below culvert;
8. Height of jump required to enter culvert;
9. Previous modifications (if any) to improve fish passage; and
10. Condition of previous modifications.

Qualitative notes describing stream habitat immediately upstream and downstream of each crossing were taken. Where feasible, variable lengths of the stream channel above and below crossings were walked to detect presence of salmonids, other fish species, and provide additional information regarding habitat conditions.

Data Entry and Passage Analyses

All survey and site visit data were recorded on waterproof data sheets. Then data for each crossing were entered into a spreadsheet. A macro was created to calculate thalweg elevations of longitudinal profiles to compute crossing and channel slopes.

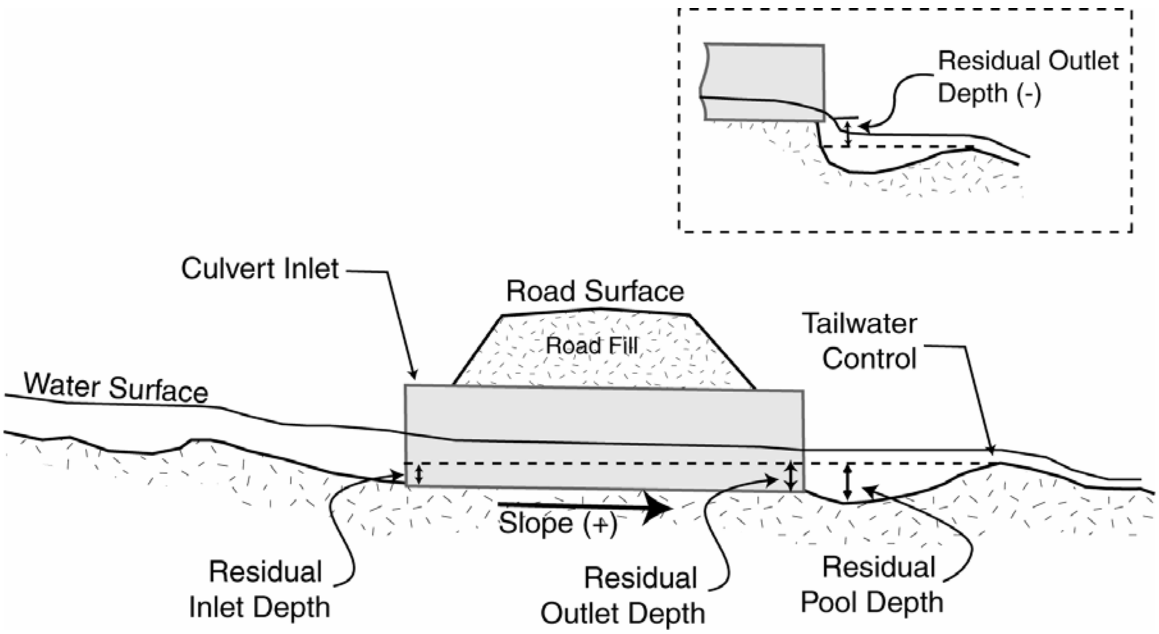
First-phase Passage Evaluation Filter: GREEN-GRAY-RED

A filtering process was used to assist in identifying sites which either met, or failed to meet, state and federal fish passage criteria for all fish species and life-stages (CDFG 2002; NMFS 2001). Using the field inventory data, the following values were calculated: average active channel width, crossing slope, residual inlet depth and residual outlet depth (drop at outlet) (Figure 3). The first-phase passage evaluation filter was employed to reduce the number of crossings which required an in-depth passage evaluation with FishXing. The filter criteria were designed to quickly classify crossings into one of three categories:

- **GREEN**: Conditions assumed adequate for passage of all salmonids, including the weakest swimming life-stage.

- GRAY: Conditions may not be adequate for all salmonid species or life-stages presumed present. Additional analyses required to determine extent of barrier for each species and life-stage.

- **RED**: Conditions do not meet passage criteria at any flows for strongest swimming species presumed present. In some instances, assume "no passage" and move to analysis of habitat quantity and quality upstream of the barrier.



Residual Pool Depth = $(\text{Elev}_{\text{Tailwater Control}} - \text{Elev}_{\text{Pool Bottom}})$

Outlet Depth = $(\text{Elev}_{\text{Tailwater Control}} - \text{Elev}_{\text{Culvert Outlet}})$ *(No outlet drop if Outlet Depth ≥ 0)*

Residual Inlet Depth = $(\text{Elev}_{\text{Tailwater Control}} - \text{Elev}_{\text{Culvert Inlet}})$

Figure 3. Measurements used in GREEN-GRAY-RED filtering criteria.

A spreadsheet macro was utilized that followed the CDFG flowchart to determine a stream crossing's status as Green, Gray, or Red (Figure 4). Depending on geographic location within California, species of interest will vary. Within anadromous-bearing watersheds, CDFG has determined that crossings classified as "Green" must meet upstream passage criteria for both adult and over-wintering juvenile salmonids at all expected migration flows.

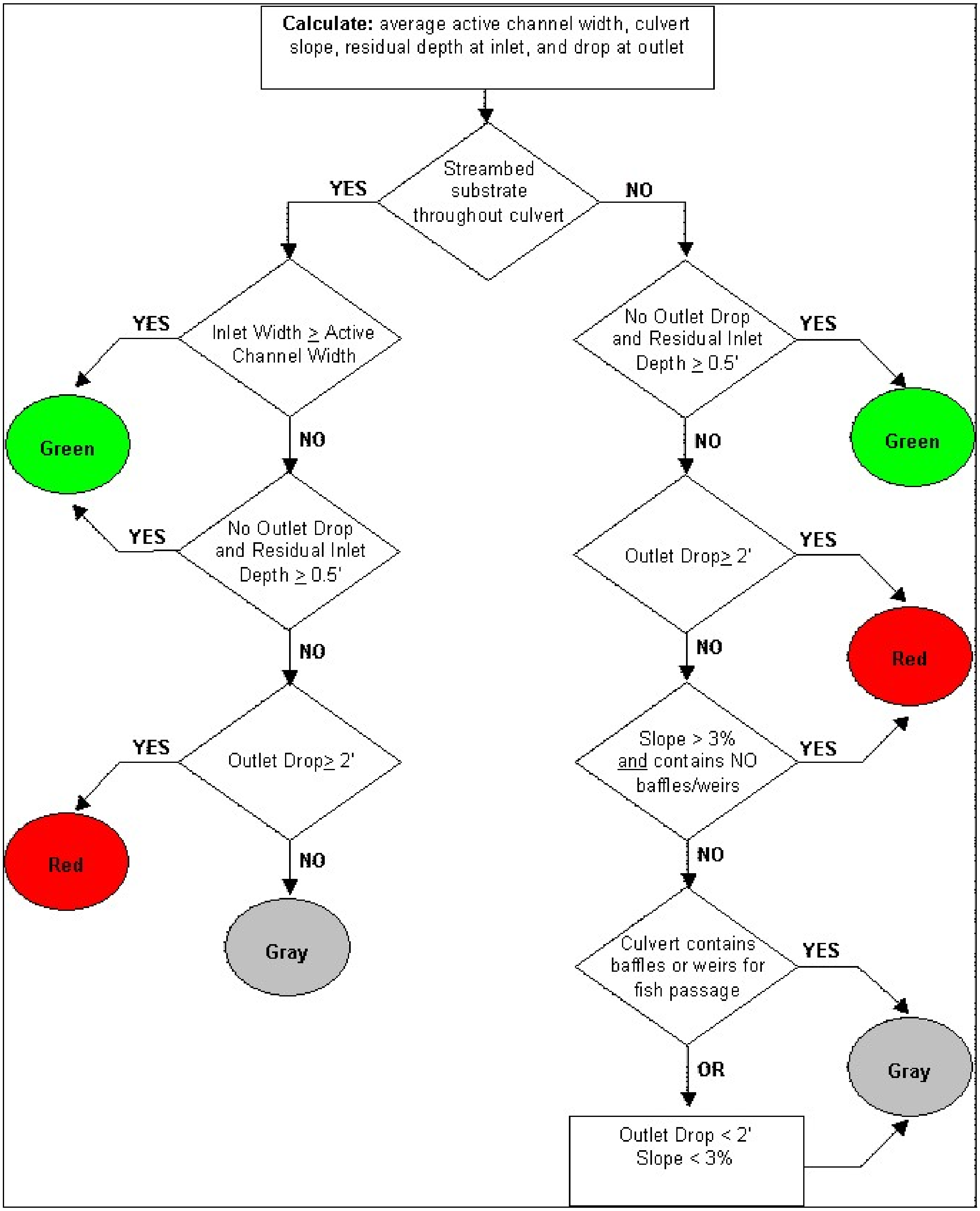


Figure 4. GREEN-GRAY-RED first-phase passage evaluation filter.

FishXing Overview

FishXing is a computer software program developed by Six Rivers National Forest's Watershed Interactions Team - a group of scientists with diverse backgrounds in engineering, hydrology, geomorphology, geology and fisheries biology. Mike Furniss, a Forest Service hydrologist for Six Rivers, managed program development. The initial version of FishXing was released in March, 2000. FishXing has since undergone two revisions, with version 3.0 due for release in fall of 2006. A beta copy of version 3.0 was utilized in the analyses of the Hopland Pomo Indian Tribe data. In-depth information regarding FishXing (or a copy of the most-recent version) may be obtained at the Fish Crossing homepage on the internet (www.stream.fs.fed.us/fishxing/).

FishXing is an interactive software package that integrates a culvert design and assessment model for fish passage nested within a multimedia educational setting. Culvert hydraulics are well understood and model output closely resembles reality. FishXing successfully models (predicts) hydraulic conditions throughout the culvert over a wide range of flows for numerous culvert shapes and sizes. The model incorporates fisheries inputs including fish species, life stages, body lengths, and leaping and swimming abilities. FishXing uses the swimming abilities to determine whether the culvert installation (current or proposed) will accommodate fish passage over a desired range of migration flows, and identify specific locations within the culvert that impede or prevent passage. Software outputs include water surface profiles and hydraulic variables such as water depths and average velocities displayed in both tabular and graphical formats.

FishXing used the survey elevation and crossing specifications to evaluate passage at each site surveyed. The swimming abilities and passage criteria used for each species and life-stage are listed Table 2. Although some individual fish will have swimming abilities surpassing those listed below, swim speeds were selected to ensure stream crossings accommodate passage of weaker individuals within each age class.

Table 2. Fish species and life stages used in the fish passage assessment along with associated swimming abilities and passage criteria. Values in parentheses are the conservative values recommended in the CDFG protocol. Passage flows are based on current adult salmonid criteria combined with observational data from northern California coastal streams.

Fish Species/Age Class	**Adult Steelhead and Coho**	**Resident Trout**	**Juvenile Salmonids**
Fish Length	500 mm	200 mm	80 mm
Prolonged Mode Swim Speed Time to Exhaustion	(6 ft/sec) **8 ft/sec** 30 min	4 ft/s 30 min	1.5 ft/s 30 min
Burst Mode Swim Speed Time to Exhaustion	(10 ft/sec) **16 ft/sec** 5 sec	5.0 ft/s 5 s	3.0 ft/s 5 s
Maximum Leaping Speed	(12.0 ft/sec) **16 ft/sec**	6.0ft/s	3.0 ft/s
Velocity Reduction Factors for Corrugated Metal Culverts **	Inlet = 1.0 Barrel = 1.0 Outlet = 1.0	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8
Minimum Required Water Depth	(0.8 ft) **0.5 ft**	0.5 ft	0.3 ft
Minimum Passage Flow *(Use the larger of the two flows)*	50% exceedance flow or 3 cfs	90% exceedance flow or 2 cfs	95% exceedance flow or 1 cfs
Maximum Passage Flow	1% exceedance flow	5% exceedance flow	10% exceedance flow

** Velocity reduction factors only apply to culverts with corrugated walls, baffles, or natural substrate. All other culverts had reduction factors of 1.0 for all fish.

FishXing and other hydraulic models report the average cross-sectional water velocity, often failing to account for spatial variations. Stream crossings with natural substrate or corrugations will have regions of reduced velocities that can be utilized by migrating fish. These areas are often too small for larger fish to use, but can enhance juvenile passage success. FishXing allows the use of reduction factors that decrease the calculated water velocities proportionally. As shown in Table 2, velocity reduction factors were used in the passage analysis of resident fish and juveniles with specific types of stream crossing structures.

Using FishXing, the range of flows that met the depth, velocity, and leaping criteria for each life-stage were identified. The range of flows meeting the passage requirements were then compared to the entire range of fish passage flows to determine "percent passable".

Hydrology and Design Flow

When examining stream crossings that require fish passage, three specific flows are considered: peak flow capacity of the stream crossing, the upper fish passage flow, and the lower fish passage flow. Because flow is not gauged on most small streams, it must be estimated using techniques that required hydrologic information about the stream crossing's contributing watershed, including:

Drainage area;
Mean annual precipitation;
Mean annual potential evapotranspiration; and
Average basin elevation.

Drainage area and basin elevations were calculated from a 1:24,000 USGS topographic map. For most projects, mean annual precipitation (MAP) and potential evapotranspiration (PET) are estimated from regional maps produced by Rantz (1968).

Peak Flow Capacity

Peak flows are typically defined in terms of a recurrence interval, but reported as a quantity; often as cubic feet per second (c.f.s.). Current guidelines recommend all stream crossings pass the flow associated with the 100-year flood without damage to the stream crossing (NOAA, 2001). Additionally, infrequently maintained crossings with culverts should accommodate the 100-year flood without overtopping the culvert's inlet.

Determination of a crossing’s flood capacity can assist in ranking sites for remediation. Undersized crossings have a higher risk of catastrophic failure, which often results in the immediate delivery of sediment from the road fill into the downstream channel. Depending on the amount of road-fill, this pulse of sediment may have a minor-to-catastrophic impact on downstream rearing and spawning habitat. Undersized crossings can also adversely affect sediment transport and downstream channel stability, creating conditions that hinder fish passage, degrade habitat, and may cause damage to other stream crossings and/or private property.

The first step was to estimate hydraulic capacity of each inventoried stream crossing. Capacity is generally a function of the shape and cross-sectional area of the inlet. Capacity was calculated for two different headwater elevations: water ponded to the top of the culvert inlet (HW/D = 1). Nomograph equations developed by Piehl et. al (1988) were used to calculate capacity of circular culverts. Federal Highways nomographs presented in Norman et al (1995) were used for pipe-arches, open bottom arches, oval pipes and box culverts.

The second step was to estimate peak flows at each crossing. This required estimating the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year peak flows. Regional flood estimation equations developed by Waananen and Crippen (1977) were used to estimate peak flows for the various recurrence intervals (Figure 5). The equations incorporate drainage area, MAP, and mean basin elevation as variables to predict peak flow in North Coast region California streams.

The third step was to compare the stream crossing capacity to peak flow estimates. Risk of failure was assessed by comparing a stream crossing’s hydraulic capacity with the estimated peak flow for each recurrence interval. Each crossing was placed into one of six “sizing” categories:

1. equal to or greater than the 100-year flow,
2. between the 50-year and 100-year flows,
3. between the 25-year and 50-year flows,
4. between the 10-year and 25-year flows,
5. between the 10-year and 5-year flows, and
6. less than the 5-year storm flow.

These six categories were utilized in the stream crossing ranking matrix.

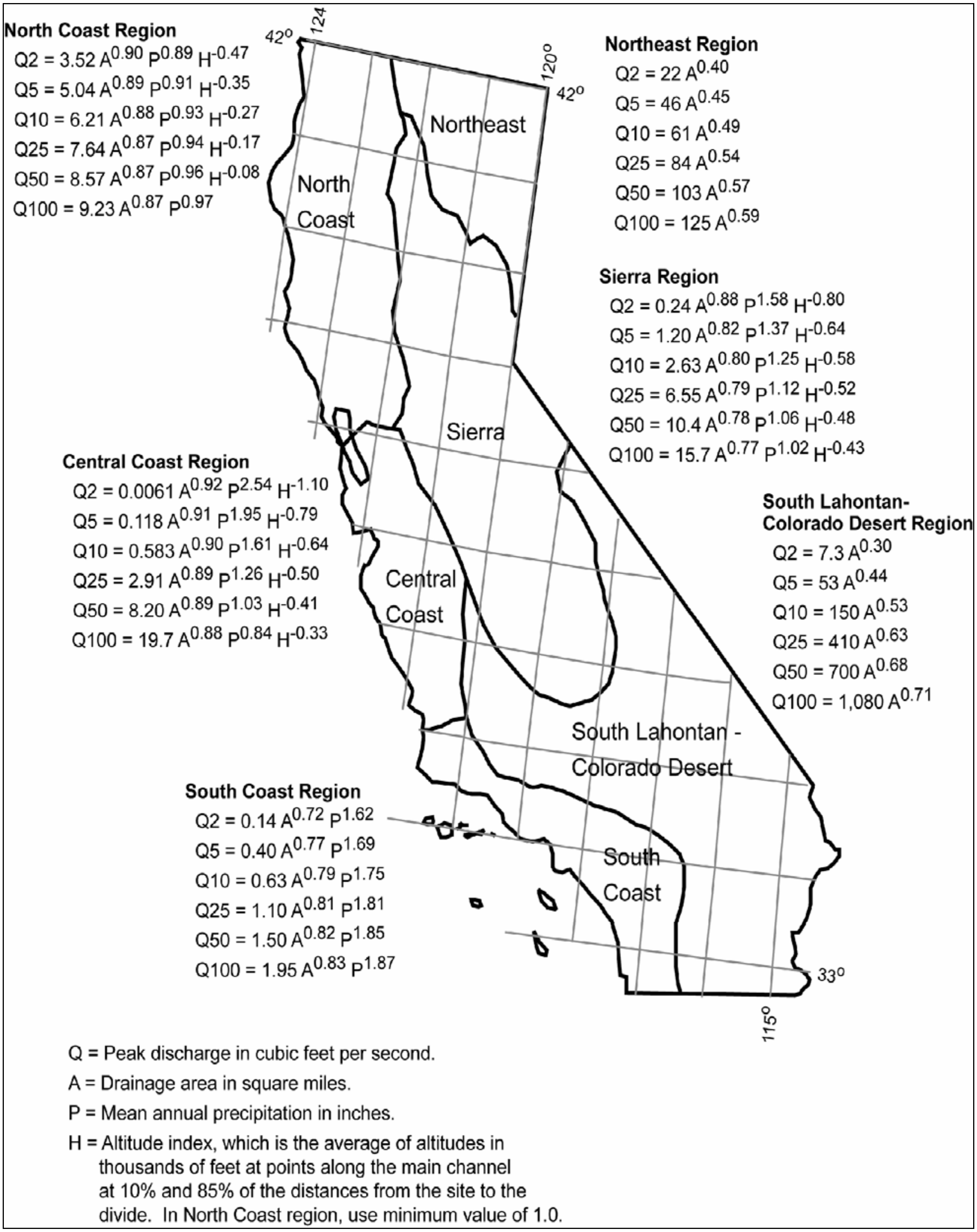


Figure 5. California regional regression equations for estimating peak flows associated with a 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year recurrence interval (Waananen and Crippen, 1977).

Fish Passage Flows

It is widely agreed that designing stream crossings to pass fish at all flows is impractical (CDFG 2002; NOAA 2001; Robison et al. 2000; SSHEAR 1998). Although anadromous salmonids typically migrate upstream during higher flows triggered by hydrologic events, it is presumed that migration is naturally delayed during larger flood events. Conversely, during low flow periods on many smaller streams, water depths within the channel can become impassable for both adult and juvenile salmonids. To identify the range of flows that stream crossings should accommodate for fish passage, lower and upper flow limits have been defined specifically for streams within California (CDFG 2002; NOAA 2001).

To evaluate the extent to which a crossing is a barrier, passage was assessed between the lower and upper passage flows for each life stage of concern. Identifying the exceedence flows required obtaining average daily stream flow data from gauged streams. Daily average flow data for small streams in the Sonoma County section of the Russian River watershed were available from the USGS.

The following steps were followed to estimate upper and lower passage flows:

1. Obtained flow records from local stream gauges that met the following requirements:
    - At least five years of recorded daily average flows (do not need to be consecutive years);
    - A drainage area less than 100 square miles, and preferably less than 10 square miles; and,
    - Unregulated flows (no upstream impoundments or water diversions) during the migration season are desired.

2. Divided the flows (Q) for each gauged stream by its drainage area (A), resulting in units of cfs/mi^2.

3. Created regional flow duration curve by taking the median of the exceedence flows (Q/A) of the gauged streams. Flow duration curves for streams in the Hopland area were originally developed for the 2003 Russian River Fish Passage Inventory by Ross Taylor and Associates.

4. Determined the upper and lower passage flows for each stream crossing using the regional flow duration curve and the drainage area of the stream crossing.

When analyzing fish passage with FishXing, these flows were used to determine the extent to which the crossing is a barrier (or fails to meet passage criteria). The stream crossing must meet water velocity and depth criteria between Q_{lp} and Q_{hp} to be considered 100% passable (NOAA 2001). For the ranking matrix, at each stream crossing, the extent of the migration barrier was determined for each salmonid species and life stage presumed present.

Initial Ranking of Stream Crossings for Treatment

The ranking objective was to arrange the sites in an order from high to low priority using a suite of site-specific information. However, the “scores” generated were not intended to be absolute in deciding the exact order of scheduling treatments. Once the first-cut ranking was completed, professional judgment played an important part in deciding the order of treatment. As noted by Robison et al. (2000), numerous social and economic factors influence the exact order of treated sites.

This report also acknowledges (but makes no attempt to quantify or prioritize) that other potentially high-priority restoration projects exist throughout the Russian River basin, and these must <u>all</u> be considered when deciding where and how to best spend limited restoration funds. However, recent research regarding watershed restoration considers the identification, prioritization, and treatment of human-made migration barriers to restore ecological connectivity for salmonids a vital (and often initial) step towards recovering depressed populations (Roni et al. 2002).

<u>Ranking Criteria</u>

The criteria and scoring for ranking stream crossings were relatively consistent with those developed for Part IX of CDFG’s *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2003), except for two aspects. The deviation from the CDFG protocol entailed reducing the weight of the current crossing’s sizing and condition scores on the site’s total score. The ranking matrix developed for the *Restoration Manual* can generate a maximum possible score of 39 points, with a maximum of 10 points (25.6%) associated with crossing condition and sizing.

Undersized crossings that are in poor condition should be of concern to road managers. However, if the primary purpose of the ranking matrix is to identify sites to treat with fisheries restoration funding, then more weight should be put on the biological-related criteria so that crossings which are serious impediments to migration with significant reaches of potential upstream habitat rank higher than crossings in need of replacement with maintenance funds.

The weight of the sizing and condition criteria score was reduced by utilizing the average of the two values. This resulted in a maximum possible total score of 34 points, with sizing and condition criteria comprising a weight of 14.7% of the maximum total score. This adjustment in scoring crossing capacity and condition has already occurred on the following projects: San Mateo County, Marin County, Russian River, Santa Cruz County, and the Morro Bay watershed fish passage assessment projects.

The method utilized for the Hopland Pomo Indian Reservation assessment assigned a score or value for the following criteria at each crossing location. The total score was the sum of four criteria: species diversity, extent of barrier, average value of crossing sizing and current condition, and total habitat score.

1. **Species diversity:** number of salmonid species known to occur (or historically occurred) within the stream reach at the crossing location. **Score:** ESA listing status as threatened: <u>Coho salmon</u> = **2** points; <u>Steelhead</u> = **2** points. NOTE: although there is historic evidence that coho salmon were probably present in the Dooley Creek watershed, there was insufficient information to determine which tributaries were coho-bearing and which were not. Thus all sites were scored as "steelhead" only.

2. **Extent of barrier:** for three age classes of salmonids (adults, resident trout/2+, and 1+/young-of-year), over the range of estimated migration flows, assign one of the following values. **Score: 0** = 80-100% passable; **1** = 60-80% passable; **2** = 40-60% passable; **3** = 20-40% passable; **4** = less than 20% passable; **5** = 0% passable (RED by first-phase evaluation filter). For a total score, sum scores given for adult species and each year-class of juveniles. **Maximum score = 15 points.**

3. **Sizing (risk of failure):** for each crossing, assign one of the following values as related to flow capacity. **Score: 0 =** sized to NMFS standards of passing 100-year flow at less than inlet height. **1** = sized for at least a 50-year flow, low risk. **2** = sized for at least a 25-year flow, moderate risk. **3** = sized for less than a 25-year flow, moderate to high risk of failure. **4** = sized for less than a 10-year event, high risk of failure. **5** = sized for less than a five-year event, high risk of failure.

4. **Current condition:** for each crossing, assign one of the following values. **Score: 0** = good condition. **1** = fair, showing signs of wear. **3** = poor, floor rusting through, crushed by roadbase, etc. **5** = extremely poor, floor rotted-out, severely crushed, damaged inlets, collapsing wingwalls, slumping road-base, etc.

5. **Crossing Score:** for each crossing, combine the sizing and condition values and compute the average value. **Maximum score = 5 points.**

6. **Habitat quantity:** above each crossing, length in feet to sustained 8% gradient. **Score:** Starting at a 500' minimum; 0.5 points for each 500' length class (**example**: **0** points for <500'; **1** point for 1,000'; **2** points for 2,000'; **3.5** points for 3,500'; and so on). **Maximum score = 10 points.**

7. **Habitat quality:** for each stream reach within the vicinity of the crossing, assign a "multiplier" of quality (relative to other streams and stream-reaches in inventory) after reviewing available habitat information.

- **Score: 1.0 = Excellent-** Relatively undeveloped, "pristine" watershed conditions. Habitat features include dense riparian zones with mix of mature native species, frequent pools, high-quality spawning areas, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. High likelihood of no future human development. Presence of migration barrier(s) is obviously the watershed's limiting factor.

- **0.75 = Good-** Habitat is fairly intact, but human activities have altered the watershed with likelihood of continued activities. Habitat still includes dense riparian zones of native species, frequent pools, spawning gravels, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. Presence of migration barrier(s) is most likely one of the watershed's primary limiting factors.

- **0.5 = Fair-** Human activities have altered the watershed with likelihood of continued (or increased) activities, with apparent effects to watershed processes and features. Habitat impacts include riparian zone present but lack of mature conifers and/or presence of non-native species, infrequent pools, sedimentation evident in spawning areas (pool tails and riffle crests), summer water temperatures periodically exceed stressful levels for salmonids, sparse in-channel complex habitat, floodplain intact or slightly modified). Presence of migration barrier(s) may be one of the watershed's limiting factors (out of several factors).

- **0.25 = Poor-** Human activities have drastically altered the watershed with high likelihood of continued (or increased) activities, with apparent effects to watershed processes. Habitat impacts include riparian zones absent or severely degraded, little or no pool formations, excessive sedimentation evident in spawning areas (pool tails and riffle crests), stressful to lethal summer water temperatures common, lack of in-channel habitat, floodplain severely modified with levees, riprap, and/or residential or commercial development. Other limiting factors within watershed are most likely of a higher priority for restoration than remediation of migration barriers.

Total habitat score: Multiply #5 by #6 for habitat "score". A multiplier assigned for habitat quality, weighs the final score more on quality than sheer quantity of upstream habitat. **Maximum score = 10 points.** For each culvert location, the five ranking criteria were entered into a spreadsheet and total scores computed. Then the list was sorted by "Total Score" in a descending order to determine an initial ranking.

On closer review of the rank, some professional judgment was used to slightly adjust the rank of several sites, primarily in regards to FishXing results. The sites were then subjectively defined as "high", "medium", or "low" priority. The high-priority sites were generally characterized as serious impediments to migration with significant amounts of upstream habitat for anadromous salmonids. Medium-priority sites were characterized as limited in upstream habitat gains and/or were only significant impediments to juvenile migration. Low-priority sites were either limited in upstream habitat, habitat condition was poor, and/or the site allowed passage of adults and most juveniles. Remediation of crossings identified as "high-priority" should be accomplished by submitting proposals to various fisheries restoration funding sources. The information provided in this report should be used to document the logical process employed to identify, evaluate, and rank these migration barriers.

RESULTS

Initial Site Visits

During the May 2006 field work, initial site visits were conducted at six stream crossings and four crossings were surveyed and included in the evaluation process (Table 3). The two sites that did not receive survey and analysis were ford crossings. At the time of the initial site visits, the ford crossings were not impeding fish passage for salmonids at any life stages. However, the ford crossings are potential sources for excess fine sediment contribution to tributaries, and should be considered for decommission if feasible.

The results section of this report also includes site characteristic and fish passage evaluation for four additional sites (Table 3), which were surveyed in a CDFG-funded 2003 Survey of county-maintained crossings within the Russian River watershed. These sites are located both upstream and downstream of sites surveyed during the 2006 Hopland Pomo Tribe project work, and should be considered along with the 2006 site surveys for any future fish passage planning efforts within the Reservation watersheds.

The following list is an overview of the crossings inventoried:

1. Three types of crossing configurations and materials were inventoried. These included circular pipe culverts (four sites), concrete box culverts (three sites) and one arch culvert with a concrete bottom.

2. The three concrete box culverts were described as in “good” condition, and reflect the longevity of concrete as a construction material. Of the four circular pipe culverts, one was described as in “good” condition (ID# Pomo-02), two were in “poor” condition (ID# M005, M006), and one was listed as in “extremely poor” condition (ID# Pomo-04). The primary reason for the poor condition of these culverts was deterioration of the invert (bottom of culvert) due to rusting caused by the abrasive force of bedload movement on high flows, a common characteristic of aging culverts constructed of circular steel. The arch culvert with a concrete bottom was described as in “fair” condition (ID #M007).

3. Seven of the crossings were undersized when compared to recently released NMFS guidelines that recommend stream crossings pass the 100-year storm flow at less than 100% of inlet height (Table 4). Six of these seven sites were significantly undersized, modeling to overtop at a recurrence interval of <10 years, while one was sized to pass grater than a 25-year storm flow.

Table 3. Site ID and Crossing Type for eight stream crossings located within the Hopland Band of Pomo Indians' Reservation in the Dooley Creek, Russian River watershed.

ID #	Stream Name	Road Name	Type of Crossing
Pomo-01	Nissa-Kah Creek	Nokomis Road	Concrete Box Culvert
Pomo-02	Tha-Layla Creek	Nokomis Road	Circular Pipe Culvert
Pomo-03	Angelica Creek #1 aka Pratt Ranch Creek	Highway 175	Circular Pipe Culvert
Pomo-04	Angelica Creek #2 aka Pratt Ranch Creek	Dirt Road - Old Hwy 175	Concrete Box Culvert
*M005	Ka-Thalay Creek #1	Pratt Ranch Road	Circular Pipe Culvert
*M006	Ka-Thalay Creek #2	Pratt Ranch Road	Circular Pipe Culvert
*M007	McDowell Creek #1	Hooper Ranch Road	Open Bottom Arch w/ concrete floor
*M008	McDowell Creek #2	Highway 175	Concrete Box Culvert

*** surveyed during 2003 Russian River survey.**

Table 4. Recurrence interval to overtop culvert for eight stream crossings located within the Hopland Band of Pomo Indians' Reservation in the Dooley Creek, Russian River watershed.

ID #	Stream Name	Road Name	Recurrence Interval to overtop culvert inlet (years)
Pomo-01	Nissa-Kah Creek	Nokomis Road	7
Pomo-02	Tha-Layla Creek	Nokomis Road	>250
Pomo-03	Angelica Creek #1 aka Pratt Ranch Creek	Highway 175	7
Pomo-04	Angelica Creek #2 aka Pratt Ranch Creek	Dirt Road - Old Hwy 175	3
***M005**	Ka-Thalay Creek #1	Pratt Ranch Road	3
*M006	Ka-Thalay Creek #2	Pratt Ranch Road	6
*M007	McDowell Creek #1	Hooper Ranch Road	3
*M008	McDowell Creek #2	Highway 175	41

***surveyed during 2003 CDFG-funded Russian River assessment**

Passage Analyses

For large study areas that include numerous road crossings and surveys, the **GREEN-GRAY-RED** first-phase evaluation filter is typically used to reduce the number of sites requiring in-depth analyses with FishXing. The initial use of the first-phase filter is followed by passage evaluations with FishXing on all **GRAY** sites. However, due to the limited number of crossings surveyed within the scope of the Hopland project, FishXing analyses were applied to all sites. Passage for adult anadromous salmonids was assessed with the more rigorous swimming abilities of 8ft/sec for prolonged swimming mode, 16 ft/sec for burst speed swimming mode and exit velocity, and a minimum water depth of 0.5 feet.

It is important to note that crossings which failed to meet the more rigorous criteria may still actually provide partial or temporal passage of adult steelhead during certain flow conditions. The values used for the passage evaluations were more rigorous than CDFG's recommended criteria, yet were still less than the maximum values recorded for adult steelhead. Some passage probably also occurs at sites where FishXing identified the only violation of the passage criteria as a lack-of-depth.

FishXing has proved to be an extremely useful tool in estimating the extent of passage at culvert sites and identifying the probable causes of blockages. However, like most models which attempt to predict complex physical and biological processes with mathematics, there were limitations and assumptions that must be acknowledged when using FishXing. Many stream crossings have site-specific characteristics that may influence hydraulics in a way that the software cannot account for, such as a box culvert outlet with an irregularly-poured concrete edge

Biological considerations are probably more difficult to account for than the physical attributes of the stream crossings in interpreting FishXing results. Over the past six winters, repeated visits to numerous crossings with culverts in northern California during migration flows revealed some confounding results generated by FishXing:

1. Adult salmonids having great difficulties entering perched culverts which FishXing suggested were easily within the species' leaping and swimming capabilities.
2. Adult salmonids successfully migrating through water depths defined as "too shallow" by current fish passage assessment and design criteria.

The behavior and abilities of fish are too varied and complex to be summed up with an equation or a number taken from a published article. Even a single fishes' leaping and swimming abilities at a culvert may change as numerous attempts are made. Extensive winter-time observations at culverts in northern California have documented individual fish become fatigued over repetitive attempts, and conversely documented other fish gaining access to culverts after numerous failed attempts (Taylor 2000-05; Love pers. comm.). Due to these factors, passage evaluation results generated by FishXing should be used conservatively in the ranking of sited for remediation by lumping "percent passable" into large (20%) categories.

For each site, the GREEN-GRAY-RED First-Phase Filter Conclusions are provided in Table 5. For each site, by age-class, FishXing evaluation results are provided in Table 6.

Table 5. GREEN-GRAY-RED first-phase filter results for eight stream crossings located within the Hopland Band of Pomo Indians' Reservation in the Dooley Creek, Russian River watershed.

ID #	Stream Name	Road Name	Conclusion from First-Phase Filter
Pomo-01	Nissa-Kah Creek	Nokomis Road	**RED**
Pomo-02	Tha-Layla Creek	Nokomis Road	**RED**
Pomo-03	Angelica Creek #1 aka Pratt Ranch Creek	Highway 175	**GRAY**
Pomo-04	Angelica Creek #2 aka Pratt Ranch Creek	Dirt Road Old Hwy 175	**GRAY**
***M005**	Ka-Thalay Creek #1	Pratt Ranch Road	**RED**
*M006	Ka-Thalay Creek #2	Pratt Ranch Road	**RED**
*M007	McDowell Creek #1	Hooper Ranch Road	**RED**
*M008	McDowell Creek #2	Highway 175	**RED**

*** surveyed during 2003 Russian River CDFG-funded inventory.**

Stream Crossing Ranking and Treatment Recommendations

The eight stream crossings were scored using the modified CDFG criteria and scores ranged from a high of 24.0 points to a low of 9.5 points (Table 7). Six of the eight stream crossings had "extent of barrier" scores of 15, indicating that these crossings failed to meet passage criteria for all age classes of steelhead, including adults. However closer examination of the FishXing results and site photos suggest that at Site ID#'s Pomo-03 and M-008 a moderate level of adult passage probably occurs due to criteria violations related to lack-of-depth within the culvert or within the outlet pool. The other four crossings have severely perched outlets that are most likely serious impediments to adult steelhead.

The three crossings recommended for high-priority treatment are Site ID# Pomo-01 (Nissa-Kah Creek at Nokomis Road), M-005 (Ka-Thalay Creek #1 at Pratt Ranch Creek Road), and M-007 (McDowell Creek #1 at Hooper Ranch Road) due to the severity of the barrier and the significant amount of potential upstream habitat. Although the concrete box culvert at Site #Pomo-01 is undersized for storm-flow conveyance, a full replacement of this crossing is most likely cost-prohibitive. Passage could be significantly improved by modifying the outlet conditions by: removing riprap and construction of either a series of boulder weirs or an engineered fish-way. Corner baffles within the box culvert would create additional depth and reduce velocity however reduction of capacity should be considered. A licensed engineer with experience in designing fish passage structures should be consulted in designing the retrofit to this stream crossing.

The current culverts at Sites #M-005 and M-007 are both severely undersized and in poor condition, thus full replacement with a properly-sized open-bottom arch or a bridge is the best long-term solution for each location. Grade-control may be required to minimize or control potential upstream head-cutting. A licensed engineer (with fish passage experience) should be consulted in designing appropriate treatments for these two stream crossings.

Table 6. FishXing percent passable results

ID#	Stream Name	Road Name	Drainage	Adult Lower Q50% or 3 cfs	Upper Q1%	%Passable	Resident Lower Q90% or 2 cfs	Upper Q5%	%Passable	Juvenile Lower Q95% or 1 cfs	Upper Q10%	%Passable
Pomo-01	Nissa-Kah Creek	Nokomis Road	Dooley Cr-Russian R	3.0	54.1	**0%**	2.0	16.0	**0%**	1.0	8.1	**0%**
Pomo-02	Tha-Layla Creek	Nokomis Road	Dooley Cr-Russian R	3.0	6.3	**67%**	2.0	2.1	**0%**	1.0	3.0	**0%**
Pomo-03	Angelica Creek #1 aka Pratt Ranch Creek	Hwy 175	Dooley Cr-Russian R	3.0	42.7	**0%**	2.0	13.0	**0%**	1.0	6.4	**0%**
Pomo-04	Angelica Creek #2 aka Pratt Ranch Creek	Old Hwy 175	Dooley Cr-Russian R	3.0	42.7	**100%**	2.0	13.0	**100%**	1.0	6.4	**85%**
*M-005	Ka-Thalay Creek #1	Pratt Ranch Road	Dooley Cr-Russian R	3.0	59.2	**0%**	2.0	18.0	**0%**	1.0	8.9	**0%**
*M-006	Ka-Thalay Creek #2	Pratt Ranch Road	Dooley Cr-Russian R	3.0	18.6	**0%**	2.0	5.6	**0%**	1.0	2.8	**0%**
*M-007	McDowell Creek #1	Hooper Ranch Road	Dooley Cr-Russian R	3.0	94.8	**0%**	2.0	28.8	**0%**	1.0	14.3	**0%**
*M-008	McDowell Creek #2	Hwy 175	Dooley Cr-Russian R	3.0	77.4	**0%**	2.0	23.6	**0%**	1.0	11.6	**0%**

*** surveyed during 2003 Russian River CDFG-funded assessment.**

Table 7. Ranked list of eight Hopland Pomo Reservation stream crossings located in anadromous-bearing stream reaches.

INITIAL RANK	Site ID#	Stream Name	Road Name	Presumed Species Diversity	Species Diversity Score	Extent of Barrier Score	Current Sizing Score	Current Condition Score	Culvert Score (ave of sizing and condition scores)	Length of habitat for scoring	Habitat Length score	Habitat Quality Modifier	Total Habitat Score	TOTAL SCORE	Comments
# 1	Pomo-03	Angelica Creek #1 aka Pratt Ranch Creek	Hwy 175	Steelhead	2	15	4	0	2	14,000	10.00	0.50	5.00	24.00	Slightly perched outlet, shallow leap pool during lower flows. Y-o-y observed upstream of culvert. Upstream habitat estimated by RTA using Terrain Navigator®
# 2	M-007	McDowell Creek #1	Hooper Ranch Road	Steelhead	2	15	5	1	3	5,900	5.90	0.58	3.44	23.44	Use CDFG habitat length estimate. Severely perched outlet that spills over apron of concrete and riprap.
# 3	M-005	Ka-Thalay Creek #1	Pratt Ranch Road	Steelhead	2	15	5	3	4	8,900	8.90	0.25	2.23	23.23	Use CDFG habitat length estimate. Severely perched outlet.
# 4	Pomo-01	Nissa-Kah Creek	Nokomis Rd	Steelhead	2	15	4	0	2	7,400	7.40	0.50	3.70	22.70	Cascade over rip-rap at outlet. Upstream habitat estimated by RTA using Terrain Navigator®
# 5	M-006	Ka-Thalay Creek #2	Pratt Ranch Road	Steelhead	2	15	4	3	3.5	1,900	1.90	0.25	0.48	20.98	Use CDFG habitat length estimate. Severely perched outlet that spills over lots of riprap.
# 6	M-008	McDowell Creek #2	HWY 175	Steelhead	2	15	2	0	1.0	2,600	2.60	0.60	1.56	19.56	Use CDFG habitat length estimate. Slightly perched outlet. Several y-o-y's observed above and below box culvert.
# 7	Pomo-02	Tha-Layla Creek	Nokomis Rd	Steelhead	2	11	0	5	2.5	2,800	2.80	0.25	0.70	16.20	Severely perched outlet. Upstream habitat estimated by RTA using Terrain Navigator®
# 8	Pomo-04	Angelica Creek #2 aka Pratt Ranch Ck	Dirt Rd (Old Hwy 175?)	Steelhead	2	0	5	0	2.5	13,900	10.00	0.50	5.00	9.50	Upstream habitat estimated by RTA using Terrain Navigator®

LITERATURE CITED

Bates, K; B. Barnard; B. Heiner; P. Klavas; and P. Powers. 1999. Fish passage design at road culverts: a design manual for fish passage at road crossings. WA Department of Fish and Wildlife. Olympia, Washington. 44 p.

CDFG. 2002. See G. Heise.

Cederholm, C.J. and W.J. Scarlett. 1981. Seasonal immigrations of juvenile salmonids into four small tributaries of the Clearwater River, Washington, 1977-1981, p. 98-110. *In* E.L. Brannon and E.O. Salo, editors. Proceedings of the Salmon and Trout Migratory Behavior Symposium. School of Fisheries, University of Washington, Seattle, WA.

Flannigan, S.A.; T.S. Ledwith; J. Ory; and M.J. Furniss. 1997. Risk assessment of culvert installations of forest roads. Water-roads Interactions Project, Six Rivers National Forest. 28 p.

Flosi, G. and F.L. Reynolds. 1994. California salmonid stream habitat restoration manual. Inland Fisheries Division, CDFG, Sacramento, California.

NMFS. 2001. Guidelines for salmonid passage at stream crossings. NOAA Fisheries, Southwest Region, Santa Rosa, CA. 11 p.

Normann, J. L., R. J. Houghtalen, and W. J. Johnston. 1985. Hydraulic Design of Highway Culverts. U.S. Department of Transportation, Federal Highway Administration, Hydraulic Design Series No. 5, 272 pp.

Piehl, B. T., M. R. Pyles, and R. L. Beschta. 1988. Flow Capacity of Culverts on Oregon Coast Range Forest Roads. Water Resources Bulletin. Vol. 24, No. 3. pp 631- 637.

Rantz, S.E. 1968. Average annual precipitation and runoff in North Coastal California. USGS, Menlo Park, CA. 3 accompanying maps. 4 p.

Roni, P., T.J.Beechie, R.E. Bilby, F.E. Leonetti, M.M. Pollack, and G.R. Pess. 2002. A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. N. Am. J. Fish. Man. 22 (1): 1-20.

Scarlett, W.J. and C.J. Cederholm. 1984. Juvenile coho salmon fall-winter utilization of two small tributaries of the Clearwater River, Jefferson County, Washington, p. 227-242. *In* J.M. Walton and D.B. Houston, editors. Proceedings of the Olympic Wild Fish Conference, March 23-25, 1983. Fisheries Technology Program, Peninsula College, Port Angeles, WA.

Skeesick, D.B. 1970. The fall immigration of juvenile coho salmon into a small tributary. Res. Rep. Fish Comm. Oregon 2: 90-95.

SSHEAR. 1998. Fish passage barrier assessment and prioritization manual. Washington Department of Fish and Wildlife, Salmonid Screening, Habitat Enhancement, and Restoration (SSHEAR) Division. 57 p.

Taylor, R.N. and M. Love. 2003. Fish passage evaluation at stream crossings. Section IX of the California Salmonid Stream Habitat Restoration Manual, CDFG Agreement #P9985035.

Tripp, D. and P. McCart. 1983. Effects of different coho stocking strategies on coho and cutthroat trout production in isolated headwater streams. Can. Tech. Rep. Fish. Aquat. Sci. 40: 452-461.

Tschaplinski, P.J. and G.F. Hartman. 1983. Winter distribution of juvenile coho salmon (*Oncorhynchus kisutch*) before and after logging in Carnation Creek, British Columbia, and some implications for over-wintering survival. Can J. Fish Aquat. Sci. 40: 452-461.

Waananen, A.O. and J.R. Crippen. 1977. Magnitude and frequency of floods in California. U.S. Geological Survey, Water Resources Investigation 77-21, Menlo Park, CA. 96 p.

PERSONAL COMMUNICATIONS

Love, Michael. Michael Love and Associates, Eureka, CA. (707)-476-8938.

Roelofs, Terry D. Professor, Fisheries Department, Humboldt State University, Arcata, CA. (707)-826-3344.

APPENDIX A: STREAM CROSSING CATALOG

SITE CATALOG OF EIGHT STREAM CROSSINGS LOCATED ON FISH-BEARING STREAM REACHES ON THE HOPLAND BAND OF POMO INDIANS RESERVATION – EAST OF HOPLAND, CA.

Angelica Creek aka Pratt Ranch Creek/Highway 175 at confluence with Dooley Creek

NOTE: For each stream crossing there are two pages – one page of site-specific information and one page of site photos. The final pages of Appendix A are two maps - one with all eight stream crossings identified and one with the six crossings within the Rancheria boundaries.

Site ID #Pomo-01: Nissa-Kah Creek/Nokomis Road; Dooley Creek; Russian River.

Road Ownership: County of Mendocino **Ranking:** High-Priority

Location: USGS Quad: Hopland. T13N, R11W, Section 15. Lat/Long: 38^{o} 58' 46.49" 123^{o} 03' 27.79" Milepost = approximately 50' to east side of Rancheria Road.

Culvert Type: Box, Concrete. **Corrugations:** None **Dimensions:** 7.0' height x 6.1 width
Length: 81.2' **Slope:** 0.01% **Modifications:** None. **Rustline Height:** N/A
Average Active Channel Width: 10.9' **Fill Estimate:** 2,463 cubic yards.
Overall condition: Good

Sizing: Extremely undersized; HW/D= 1 on a storm flow with approximately a seven-year recurrence interval. Nokomis Road is overtopped on approximately an 82-year storm flow.

Barrier Status: RED: the Green-Gray-Red filter determined this crossing fails to meet passage criteria for adult steelhead and all age classes of juveniles. The perched outlet that cascades over rip-rap at the outlet is the main feature that prevents fish migration. The concrete bottom also creates a depth barrier at lower flows.

Additional Stream Crossings: Downstream – (≈1,950') to McDowell Creek site #M-008. Upstream – None indicated on the USGS topographic map within the fish-bearing stream reach.

Habitat: Quantity = approximately 7,490' of potential fish-bearing habitat upstream of Site ID# Pomo-01. Quality = rated as "fair" for the ranking matrix – determined by Ross Taylor and Associates (RTA) observations at time of survey. No current habitat typing or fisheries surveys were available for Nissakah Creek. The crossing was surveyed by RTA on 05/24/06 at 4:00 PM. The water temperature was 15^{o}C and the air temperature was 24^{o}C. The survey crew noted a dense riparian cover and several small pools, with cobbles and gravels as the dominant substrate. Several young-of-year salmonids were observed at the site, as well as a single age-1+ juvenile salmonid upstream of the culvert.

Preferred Treatment: Because the culvert is severely undersized, a full replacement with a properly-sized open-bottom arch or a bridge is the best long-term solution to provide unimpeded passage and adequate storm-flow conveyance, however this would be cost-prohibitive since this box culvert is a new installation (under construction in 2001 when site was visited by RTA for the Russian River assessment). Passage could be significantly improved by modifying the outlet conditions by removing rip-rap and construction of either a series of boulder weirs or an engineered fish-way. Corner baffles within the box culvert would create additional depth and reduce velocities however further reduction of already limited storm flow capacity should be considered. A licensed engineer with experience in designing fish passage structures should be consulted in designing the retrofit to this stream crossing.

Site ID #Pomo-01: Nissa-Kah Creek/Nokomis Road; Dooley Creek; Russian River

Site ID #Pomo-02: Tha-Layla Creek/Nokomis Road; Dooley Creek; Russian River

Road Ownership: County of Mendocino **Ranking:** Low-Priority

Location: USGS Quad: Hopland. T13N, R11W, Section 15. Lat/Long: 38^o 58' 47.32" 123^o 03' 28.87" Milepost = at intersect of Nokomis and Rancheria Roads.

Culvert Type: Circular, CSP. **Corrugations:** 2-2/3"x ½" **Dimensions:** diameter = 4.0' **Length:** 86.5' **Slope:** 1.88% **Modifications:** None. **Rustline Height:** 0.9' **Average Active Channel Width:** 9.3' **Fill Estimate:** 1,863 cubic yards. **Overall condition:** Extremely poor, culvert invert is rusted through.

Sizing: Properly sized; HW/D= 1 on a storm flow >250 year recurrence interval. Nokomis Road is overtopped on >250-year storm flow. However the culvert diameter is undersized relative to the average active channel width.

Barrier Status: RED: the Green-Gray-Red filter determined this crossing fails to meet passage criteria for adult steelhead and all age classes of juveniles. However when assessed with FishXing for adult steelhead, passage criteria were met on 67% of the range of migration flows. The severely perched outlet is the main feature that impedes fish migration.

Additional Stream Crossings: Downstream – (≈1,950') to McDowell Creek site #M-008. Upstream – None indicated on the USGS topographic map within the fish-bearing stream reach.

Habitat: Quantity = approximately 2,900' of potential fish-bearing habitat upstream of Site ID# Pomo-02. Quality = rated as "poor" for the ranking matrix – determined by Ross Taylor and Associates (RTA) observations at time of survey. No current habitat typing or fisheries surveys were available for this tributary. The crossing was surveyed by RTA on 05/25/06 and there were isolated areas of surface water. The survey crew noted a moderately dense riparian canopy, but poor habitat conditions within the active channel – extremely turbid water in isolated pools that were highly embedded with a sand/silt substrate.

Preferred Treatment: Because of the limited quantity of available upstream habitat and the poor quality of in-stream conditions, treatment of this site would not be cost-effective and would yield minimal benefit to salmonid populations within the watershed. Recommend periodic inspection of crossing for plugging of debris at the inlet and continued failure of the culvert invert. When the crossing is replaced for maintenance purposes, fish passage should be facilitated.

Site ID #Pomo-02: Tha-Layla Creek/Nokomis Road; Dooley Creek; Russian River

NOTE: unable to obtain photo of culvert inlet due to poor access to upstream side of crossing.

Site ID #Pomo-03: Angelica Creek #1 aka Pratt Ranch Creek/Highway 175; Dooley Creek; Russian River

Road Ownership: CalTrans **Ranking:** Moderate-Priority

Location: USGS Quad: Hopland. T13N, R11W, Section 15. Lat/Long: 38^o 58’ 42.71” 123^o 03’ 52.34” Milepost = 3.18.

Culvert Type: Circular, SSP. **Corrugations:** 2-2/3”x ½” **Dimensions:** diameter = 8.0’ **Length:** 71’ **Slope:** 0.86% **Modifications:** None. **Rustline Height:** 3.4’ **Average Active Channel Width:** 12.3’ **Fill Estimate:** 2279 cubic yards. **Overall condition:** Good

Sizing: Extremely undersized; HW/D= 1 on a storm flow with approximately a seven-year recurrence interval. Highway 175 is overtopped on approximately a 23-year storm flow.

Barrier Status: Gray: the Green-Gray-Red filter defined this crossing as a partial and/or temporal barrier. FishXing calculated this site failed to meet passage criteria for all life stages of salmonids at all migration flows, although it is possible some older juveniles and adult steelhead may successfully negotiate the culvert during moderate flows. The shallow leap pool at the perched outlet along with depth barriers within the culvert, were the primary features impeding passage at this site. The culvert’s outlet is probably backwatered by Dooley Creek on higher migration flows

Additional Stream Crossings: Downstream – (≈2,250’) to Site ID #M-007. Upstream – (≈20’) to Site ID #Pomo-04, (≈3,750’) to Site ID #M-005 and (≈4,850’) to Site ID #M-006.

Habitat: Quantity = approximately 14,000’ of potential fish-bearing habitat upstream of Site ID# Pomo-03. Quality = rated as “fair” for the ranking matrix – determined by Ross Taylor and Associates observations at time of survey. No current habitat typing or fisheries surveys were available for Pratt Ranch Creek. The crossing was surveyed by RTA on 05/25/06 at 1:00 PM and there was constant surface water flow– the water temperature was 17^{o}C and the air temperature was 19^{o}C. The survey crew noted a dense riparian canopy and several small pools. Some areas of good spawning gravels were noted. Moderately abundant numbers (50-100 fish) young-of-year salmonids were observed upstream and downstream of this culvert.

Preferred Treatment: Because of current culvert’s poor sizing, a full replacement with a properly-sized open-bottom arch or a bridge is the best long-term solution to provide unimpeded passage and adequate storm-flow conveyance. Site ID# Pomo-04 should be removed at the same time as a replacement is constructed at Pomo-03.

Site ID #Pomo-03: Angelica Ck #1 aka Pratt Ranch Ck/Highway 175; Dooley Ck; Russian River

Site ID #Pomo-04: Angelica Creek #2 aka Pratt Ranch Creek/Old Highway 175; Dooley Creek; Russian River

Road Ownership: CalTrans? **Ranking:** Moderate-Priority

Location: USGS Quad: Hopland. T13N, R11W, Section 15. Lat/Long: 38° 58' 43.62" 123° 03' 51.84" Milepost = 3.18

Culvert Type: Box, Concrete. **Corrugations:** None **Dimensions:** 7.3' height x 5.9' width **Length:** 36.7' **Slope:** 0.32% **Modifications:** None. **Rustline Height:** N/A **Average Active Channel Width:** 12.3 **Fill Estimate:** 565 cubic yards. **Overall condition:** Good

Sizing: Extremely undersized; HW/D= 1 on a storm flow with approximately a three-year recurrence interval. Old Hwy 175 (an unpaved road) is overtopped on approximately a 12-year storm flow.

Barrier Status: Gray: the Green-Gray-Red filter defined this crossing as a partial and/or temporal barrier. FishXing estimated this site passes 100% of adult and resident age class salmonids over the entire range of migration flows. FishXing estimated the site meets juvenile salmonid passage criteria on 85% of the calculated migration flows. At higher flows, velocities within the culvert may cause juvenile fish to become exhausted before they are able to reach the inlet end.

Additional Stream Crossings: Downstream – (≈20') to Site ID# Pomo-03, and (≈2,250') to Site ID# M-007. Upstream – (≈3,700') to Site ID# M-005 and (≈4,850') to Site ID# M-006.

Habitat: Quantity = approximately 13,900' of potential fish-bearing habitat upstream of Site ID# Pomo-04. Quality = rated as "fair" for the ranking matrix – determined by Ross Taylor and Associates observations at time of survey. No current habitat typing or fisheries surveys were available for Pratt Ranch Creek. The crossing was surveyed by RTA on 05/25/06 at 1:00 PM and there was continuous surface water flow– the water temperature was 17°C and the air temperature was 19°C. The survey crew noted a dense riparian canopy and several small pools. Some areas of good spawning gravels were noted. Moderately abundant numbers (50-100 fish) young-of-year salmonids were observed upstream and downstream of this culvert.

Preferred Treatment: Because current box culvert appears to be an abandoned Caltrans crossing which serves no transportation purposes, removal of this culvert and restoration of the natural stream banks is recommended.

Site ID #Pomo-04: Angelica Ck #2 aka Pratt Ranch Ck/Old Highway 175; Dooley Creek; Russian River

Site ID #M-005: Ka-Thalay Creek #1/Pratt Ranch Road; Dooley Creek; Russian River

Road Ownership: County

Final County Ranking: #2 = High-Priority **Basin-wide Ranking:** #10 = High-Priority

Location: Road ID# 116A; County Map Sheet #3H35. USGS Quad: Hopland. T13N, R11W, Section 15. Lat/Long: 38^o 59' 11.49" 123^o 03' 31.31" Milepost = 0.9 miles to Highway 175.

Culvert Type: Circular, SSP. **Corrugations:** 2-2/3"x ½" **Dimensions:** diameter = 5.5' **Length:** 122.4' **Slope:** 1.53% **Modifications:** None. **Rustline Height:** 2.0' **Average Active Channel Width:** 9.0' **Fill Estimate:** 5375 cubic yards. **Overall condition:** Poor, culvert invert is rusted through.

Sizing: Extremely undersized; HW/D= 1 on a storm flow with approximately a three-year recurrence interval. Pratt Ranch Road is overtopped on approximately a 50-year storm flow. The more than 5,000 cubic yards of fill material in road prism would impact downstream fisheries habitat.

Barrier Status: RED: the Green-Gray-Red filter determined this crossing fails to meet passage criteria for adult steelhead and all age classes of juveniles. The severely perched outlet is the main feature that prevents fish migration.

Additional Stream Crossings: Downstream – (≈100') survey crew noted a splashboard dam structure about 3'.5 high (no boards in at time of survey) and (≈4,200') to crossing on Highway 175. Upstream – (≈1,100') to Pratt Ranch Creek #2 – Site ID #M-006.

Habitat: Quantity = approximately 8,900' of potential fish-bearing habitat upstream of Site ID# M005. Quality = rated in 2003 as "poor" for the ranking matrix – determined by CDFG's professional judgment (Coey, pers. comm.). No current habitat typing or fisheries surveys were available for Pratt Ranch Creek. The crossing was surveyed by RTA on 10/11/01 at 8:30AM and there were isolated areas of surface water – the water temperature was 11^{o}C and the air temperature was 18^{o}C. The survey crew noted a moderate riparian canopy of hardwoods and highly embedded substrate. There was a local that owns upstream property and hangs out in culvert (has built a platform at outlet – see photo) – says he sees adult steelhead every year trying to migrate through the culvert (not sure of his reliability).

Preferred Treatment: Because of current culvert's poor sizing and condition, a full replacement with a properly-sized open-bottom arch or a bridge is the best long-term solution. Grade-control may be required to minimize or control potential upstream head-cutting. Upstream landowner did not want government agencies on his property (but not sure if his property is within potential project area).

NOTE: This crossing information was collected by Ross Taylor and Associates in 2003 during a CDFG-funded assessment of county-maintained crossings within the Russian River watershed.

Site ID #M-005: Ka-Thalay Creek #1/Pratt Ranch Road; Dooley Creek; Russian River

Site ID #M-006: Ka-Thalay Creek #2/Pratt Ranch Road; Dooley Creek; Russian River

Road Ownership: County

Final County Ranking: #8 = High-Priority **Basin-wide Ranking:** #22 = Moderate-Priority

Location: Road ID# 116A; County Map Sheet #3H35. USGS Quad: Hopland. T13N, R11W, Section 15. Lat/Long: 38^{o} 59' 20.70" 123^{o} 03' 27.11" Milepost= 1.1 miles to Highway 175.

Culvert Type: Circular, SSP. **Corrugations:** 2-2/3"x ½" **Dimensions:** diameter= 4.5' **Length:** 56.7' **Slope:** 3.90% **Modifications:** None. **Rustline Height:** 1.1' **Average Active Channel Width:** 6.5'

Fill Estimate: 335 cubic yards. **Overall condition:** Poor, culvert invert is rusted through.

Sizing: Extremely undersized; HW/D= 1 on a storm flow with approximately a six-year recurrence interval. Pratt Ranch Road is overtopped on approximately a 28-year storm flow.

Barrier Status: RED: the Green-Gray-Red filter determined this crossing fails to meet passage criteria for all species of adult salmonids and all age classes of juveniles. Excessively perched outlet that drops over riprap prevents fish migration.

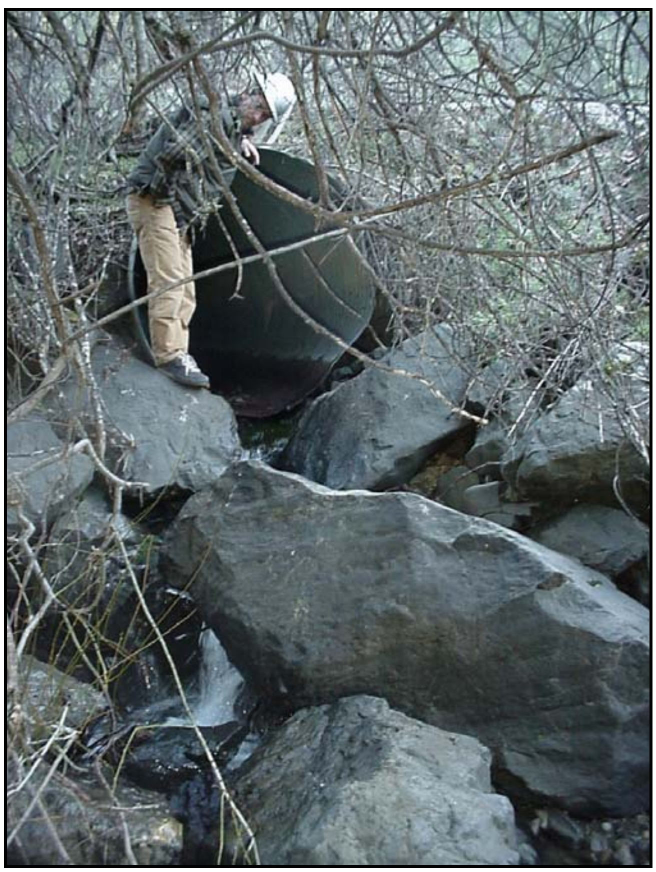
Additional Stream Crossings: Downstream – (≈1,100') to Site ID #M-006, (≈1,200') to splashboard dam structure about 3'.5 high (no boards in at time of survey) and (≈5,300') to crossing on Highway 175. Upstream – no crossings indicated on USGS map within the fish-bearing stream reach.

Habitat: Quantity = approximately 1,900' of potential fish-bearing habitat upstream of Site ID# M006. Quality = rated as "poor" for the ranking matrix – determined by CDFG's professional judgment (Coey, pers. comm.). No current habitat typing or fisheries surveys were available for Pratt Ranch Creek. The crossing was surveyed by Taylor and Assoc. on 10/11/01 at 9:30AM and the channel was dry (site photos taken later during winter). The survey crew noted a moderate riparian canopy of hardwoods and cobble and gravel substrate.

Preferred Treatment: Because of current culvert's poor sizing and condition, a full replacement with a properly-sized open-bottom arch or a bridge is the best long-term solution. Grade-control may be required to minimize or control potential upstream head-cutting. Limited amount of poor-quality habitat upstream of this crossing renders this site a low-priority to treat with restoration funding.

NOTE: This crossing information was collected by Ross Taylor and Associates in 2003 during a CDFG-funded assessment of county-maintained crossings within the Russian River watershed.

Site ID #M-006: Ka-Thalay Creek #2/Pratt Ranch Road; Dooley Creek; Russian River



Site ID #M-007: McDowell Creek #1/Hooper Ranch Road; Dooley Creek; Russian River

Road Ownership: Private

Final County Ranking: #1 = High-Priority **Basin-wide Ranking:** #9 = High-Priority

Location: County Map Sheet #3H35. USGS Quad: Hopland. T13N, R11W, Section 23. Lat/Long: 38^{o} 58' 13.32" 123^{o} 01' 59.60" Milepost = 0.05 miles to Highway 175.

Culvert Type: Arch, SSP with Concrete floor. **Corrugations:** 6"x 2" **Dimensions:** 10.4' rise x 12.5 span **Length:** 39.4' **Slope:** 1.27% **Modifications:** None. **Rustline Height:** Below footings. **Average Active Channel Width:** 13.6' **Fill Estimate:** 1,175 cubic yards. **Overall condition:** Fair.

Sizing: Extremely undersized; HW/D = 1 on a storm flow with approximately a three-year recurrence interval. Hooper Ranch Road is overtopped on approximately a five-year storm flow.

Barrier Status: RED: the Green-Gray-Red filter determined this crossing fails to meet passage criteria for adult steelhead and all age classes of juveniles. The steep drop (100% slope) over concrete and riprap at the culvert outlet are the crossing's main feature that impedes fish migration.

Additional Stream Crossings: Downstream – there are three bridges that cross Dooley Creek. Upstream – (≈450') to private bridge and (≈4,050') to McDowell Creek #2 - Site ID# M-008.

Habitat: Quantity = approximately 5,900' of potential fish-bearing habitat upstream of Site ID# M007. Quality = rated as "fair" for the ranking matrix (quality score = 0.58) – as determined by CDFG's habitat survey conducted in 1998. CDFG observed juvenile steelhead throughout the 20,000 foot reach surveyed. The crossing was surveyed by RTA on 11/7/01 at 4:00PM and there was continuous flow in the channel. Water temp = 10^{o}C and air temp = 12^{o}C. The survey crew described the habitat as "good" and noted a dense riparian canopy of hardwoods and good-quality spawning substrate of cobble and gravel – no salmonids were observed. McDowell Creek may support a population of resident coastal rainbow trout.

Preferred Treatment: Because of current culvert's poor sizing and condition, a full replacement with a properly-sized open-bottom arch or a bridge is the best long-term solution. Grade-control structures will be required to minimize or control upstream head-cutting of the channel.

NOTE: This crossing information was collected by Ross Taylor and Associates in 2003 during a CDFG-funded assessment of county-maintained crossings within the Russian River watershed.

<u>Site ID #M-007:</u> <u>McDowell Creek #1/Hooper Ranch Road; Dooley Creek; Russian River</u>

Site ID #M-008: McDowell Creek #2/Highway 175; Dooley Creek; Russian River

Road Ownership: CalTrans

Final County Ranking: Tied for #13 = Moderate-Priority **Basin-wide Ranking:** less than 20.0 points – not ranked

Location: Road ID # 175; County Map Sheet #3H35. USGS Quad: Hopland. T13N, R11W, Section 24. Lat/Long: 38^{o} 58' 20.41" 123^{o} 01' 11.73" Milepost = 5.7 miles

Culvert Type: Box, Concrete. **Corrugations:** None. **Dimensions:** 7.7' height x 10.0 width **Length:** 54.7' **Slope:** 4.17% **Modifications:** None. **Rustline Height:** N/A **Average Active Channel Width:** 12.5' **Fill Estimate:** 1580 cubic yards. **Overall condition:** Good.

Sizing: Extremely undersized; HW/D = 1 on a storm flow with approximately a 41-year recurrence interval. Highway 175 is overtopped on more than a 250-year storm flow.

Barrier Status: RED: the Green-Gray-Red filter determined this crossing fails to meet passage criteria for all species of adult salmonids and all age classes of juveniles. The culvert's 4% slope creates excessive velocities on most flows.

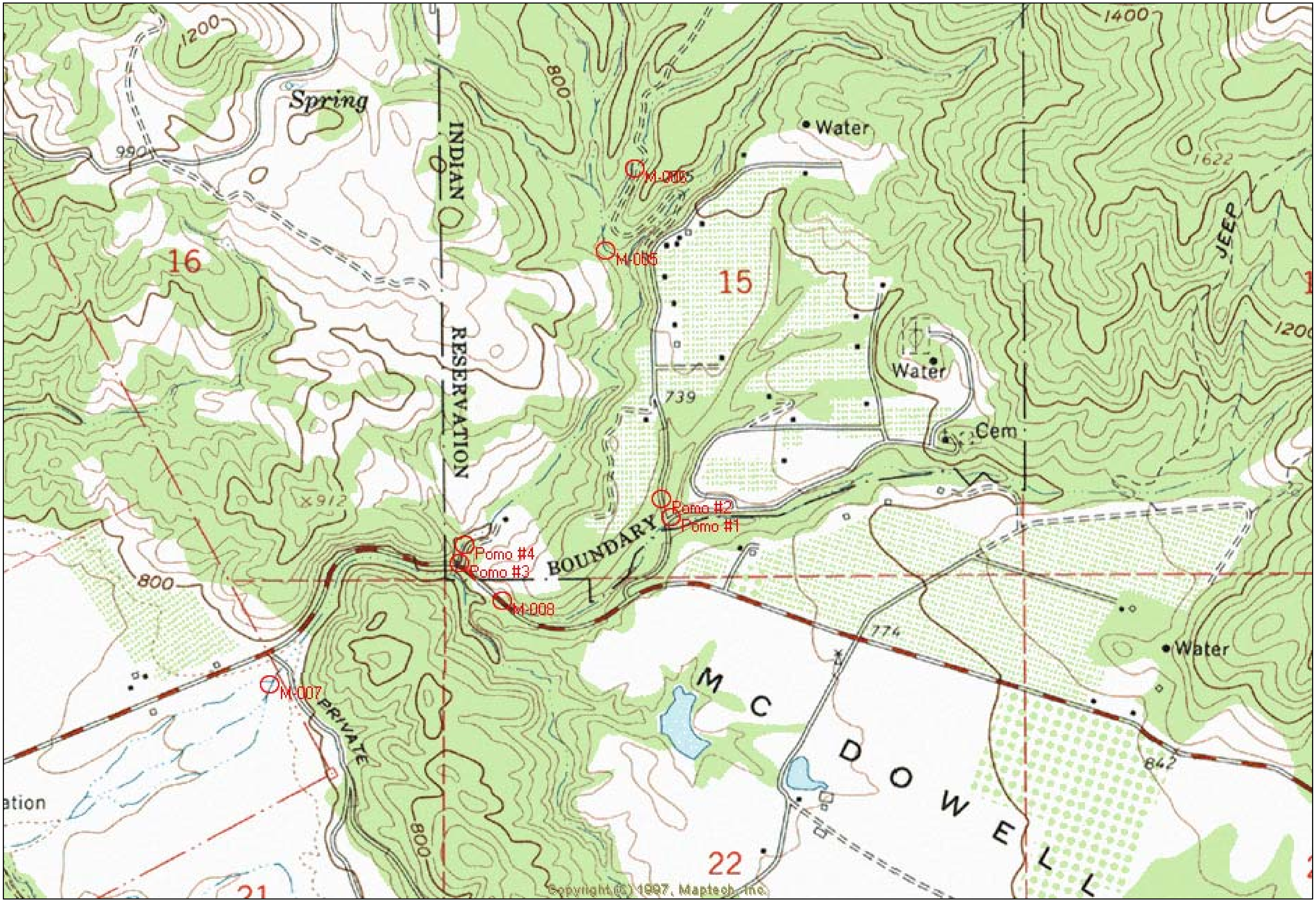
Additional Stream Crossings: Downstream – (≈3,600') to private bridge, (≈4,050') to McDowell Creek #1 - Site ID# M-007, and then three bridges that cross Dooley Creek. Upstream – none indicated on USGS map within fish-bearing stream reach.

Habitat: Quantity = approximately 2,600' of potential fish-bearing habitat upstream of Site ID# M008. Quality = rated as "fair/good" for the ranking matrix (quality score = 0.60) – as determined by CDFG's habitat survey conducted in 1998. CDFG observed juvenile steelhead throughout the 20,000 foot reach surveyed. The crossing was surveyed by RTA on 11/7/01 at 4:00PM and there was continuous flow in the channel. Water temp = 10^{o}C and air temp = 12^{o}C. The survey crew described the habitat as "good" and noted a dense riparian canopy of hardwoods and good-quality spawning substrate of cobble and gravel. The culvert survey crew also observed several young-of-year salmonids both upstream and downstream of this crossing. McDowell Creek may support a population of resident coastal rainbow trout.

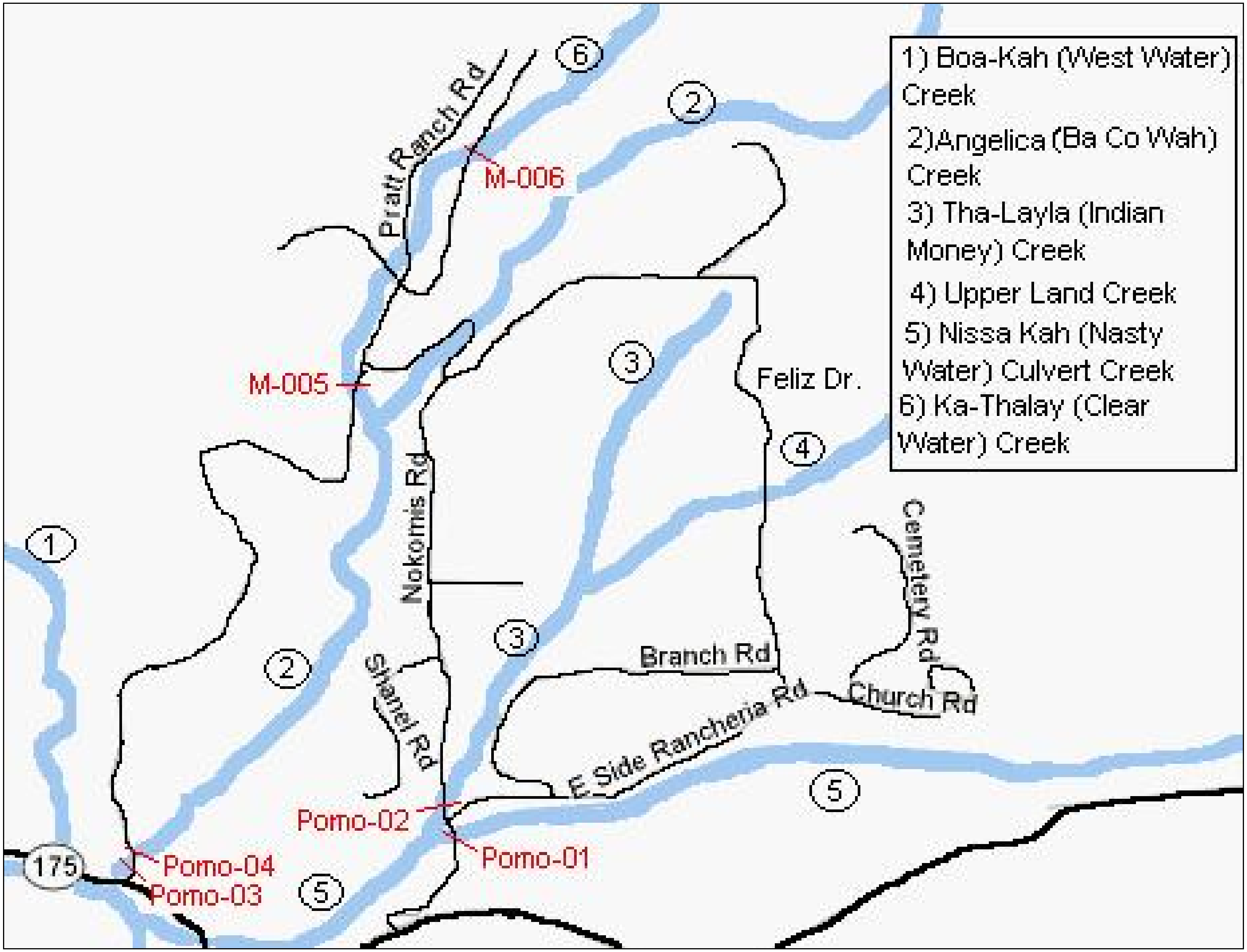
Preferred Treatment: Because the current box culvert is sized for nearly a 50-year flow, is in good condition, and there's a limited reach of upstream habitat - a retrofit is recommended to cost-effectively improve passage. Retrofit should include several downstream boulder weirs to raise tail-water elevation (and possibly back-water culvert) and corner baffles within the box culvert to reduce velocities and increase water depths at lower migration flows.

NOTE: This crossing information was collected by Ross Taylor and Associates in 2003 during a CDFG-funded assessment of county-maintained crossings within the Russian River watershed.

Site ID #M-008: McDowell Creek #2/Highway 175; Dooley Creek; Russian River



Spring
INDIAN RESERVATION BOUNDARY
Water
M-005
M-006
16
15
Water
739
Cem
Pomo #2
Pomo #1
Pomo #4
Pomo #3
M-008
M-007
PRIVATE
MC DOWELL
774
842
Water
JEEP
1400
1200
800
990
1622
22
21
Copyright (C) 1997, Maptech, Inc.


1) Boa-Kah (West Water) Creek
2)Angelica (Ba Co Wah) Creek
3) Tha-Layla (Indian Money) Creek
4) Upper Land Creek
5) Nissa Kah (Nasty Water) Culvert Creek
6) Ka-Thalay (Clear Water) Creek
Pratt Ranch Rd
M-006
M-005
Feliz Dr.
Nokomis Rd
Cemetery Rd
Branch Rd
Shanel Rd
Church Rd
E Side Rancheria Rd
Pomo-02
Pomo-01
Pomo-04
Pomo-03
175
1
2
3
4
5
6

Habitat Typing Surveys of Russian River Tributaries located on the Hopland Band of Pomo Indians Reservation

Conducted by
Ross Taylor and Associates (RTA)

For the Hopland Band of Pomo Indians' Environmental Protection Agency (EPA) Department

Acknowledgements

This project was funded by a United States Fish and Wildlife Service Tribal Wildlife Grant.

Kris Carré: managed the contract, reviewed the draft report and coordinated field support with Tribal members. Kris also made sure that I got out of the creek safely at the end of each field day.

Maura Darbro: assisted with habitat typing surveys and reviewed the draft report.

Shawn Pady: assisted with habitat typing surveys and provided four decades of personal observations regarding the creeks and fisheries.

Ricky Parrish: assisted with habitat typing surveys.

Introduction and Methods

In March and April of 2007 RTA conducted habitat typing surveys on two Russian River tributaries that flow through the Hopland Band of Pomo Indians reservation, located east of Hopland, CA. The two creeks (Angelica Creek and NissaKah Creek) both flow into McDowell Creek, a tributary to Dooley Creek which enters the Russian River just north of the town of Hopland.

The habitat typing objectives included:

- Assessing current spawning and rearing conditions for coastal rainbow trout (*Oncorhynchus mykiss irideus*) and its anadromous life history form, the steelhead.

- Generating a baseline assessment of habitat conditions for future comparisons.

- Locating reaches with perennial flow and better quality over-summering habitat for juvenile steelhead rearing.

- Assessing the quantity and quality of habitat upstream of previously identified barriers at road crossings to facilitate the treatment of these migration impediments.

Field assessment methods were fairly consistent with Part III of the California Department of Fish and Game (CDFG) *California Salmonid Stream Habitat Restoration Manual* (Flosi and Reynolds 1994). However, riparian canopy density was not measured because the habitat assessment was conducted in early spring prior to the riparian vegetation being fully leafed-out. The habitat typing assessment was conducted in the early spring so that the fisheries consultant could examine the channels with flowing water, increase chances of observing adult steelhead, completed redds and/or emergent fry, and to complete the surveys before the stream channels were overgrown with poison oak and Himalayan black berry vines.

In addition to habitat typing information collected when following the CDFG protocol, RTA measured the amount (area in ft^2) of spawning substrate in pool-tails or within other habitat units that appeared to contain areas suitable for adult steelhead spawning. Observations of salmonids and amphibians were also recorded. The CDFG-modified data sheet utilized is provided in Appendix A.

Lengths of habitat units were measured to nearest foot with a hip-chain and depths and widths were measured with a stadia rod to the nearest $1/100^{th}$ of a foot. Water and shaded air temperatures were taken at the start of each data sheet (every ten units). A handheld GPS unit was used to measure lat/long, typically at the start of each data sheet when satellite coverage was adequate.

The CDFG methodology defined habitat unit types at four different levels with Level I units defined in two primary categories: pools and riffles. Level II categories included pools, riffles and flat-water (Table 1). Level III categories habitat units were further classified into pools (main channel, scour and back-water), riffles (riffle and cascade) and flat-water (Table 1). At Level IV, 25 distinct habitat types were defined, as based on stream gradient and formation factors (Table 1).

Table 1. Level II through Level IV habitat types as defined in the CDFG Restoration Manual. The abbreviations within the parentheses for Level IV habitat types were used on the field forms.

LEVEL II	LEVEL III	LEVEL IV
RIFFLE	RIFFLE	Low Gradient Riffle (LGR)
		High Gradient riffle (HGR)
	CASCADE	Cascade (CAS)
		Bedrock Sheet (BRS)
FLATWATER	FLATWATER	Pocket Water (POW)
		Glide (GLD)
		Run (RUN)
		Step Run (SRN)
		Edgewater (EDW)
POOL	MAIN CHANNEL	Trench Pool (TRP)
		Mid-Channel Pool (MCP)
		Channel Confluence Pool (CCP)
		Step Pool (STP)
	SCOUR	Corner Pool (CRP)
		Lateral Scour Pool – Log (LSL)
		Lat. Scour Pool – Root Wad (LSR)
		Lat. Scour Pool – Bedrock (LSBk)
		Lat. Scour Pool – Boulder (LSBo)
		*Lat Scour Pool – Bank (LSBank)
		Plunge Pool (PLP)
	BACKWATER	Secondary Channel Pool (SCP)
		Backwater Pool – Boulder (BPB)
		Backwater Pool – Root Wad (BPR)
		Backwater Pool – Log (BPL)
		Dammed Pool (DPL)
ADDITIONAL UNIT DESIGNATIONS		Dry Channel (DRY)
		Culvert crossing (CUL)

***Not designated in the CDFG protocol, but was encountered during the Hopland surveys.**

For more information regarding the habitat typing protocol, habitat unit descriptions, channel type descriptions; the CDFG restoration manual is located at the following website: http://www.dfg.ca.gov/fish/Resources/HabitatManual.asp

Results – Watershed Description of Angelica Creek

Angelica Creek (aka Pratt Ranch Creek) is a second-order stream with a drainage area of approximately 2.4 square miles. Watershed elevations are approximately 700' at the mouth to 2,600' at the headwaters. The confluence of Angelica Creek and McDowell Creek is located at N38.9786292 W123.0644771 on the Hopland USGS Quadrangle map in Mendocino County (Figure 1). Nearly 6,800 feet of Angelica Creek's main channel was habitat-typed, as delineated by the red line in Figure 1. Several tributaries to Angelica Creek were not assessed due to their small size and relatively minor contribution of flow to the main channel. The upper limit of the Angelica Creek survey was at a plunge pool created by large slide and woody debris jam, the drop over the jam was approximately three to four feet. The channel at this location had also narrowed to a wetted width of three feet or less and had an active channel width of approximately five feet. Although the stream channel at this location (and immediately above the debris jam) probably still had fish-bearing potential; it was uncertain, while in the field, if the location was still within reservation boundaries or onto private property.

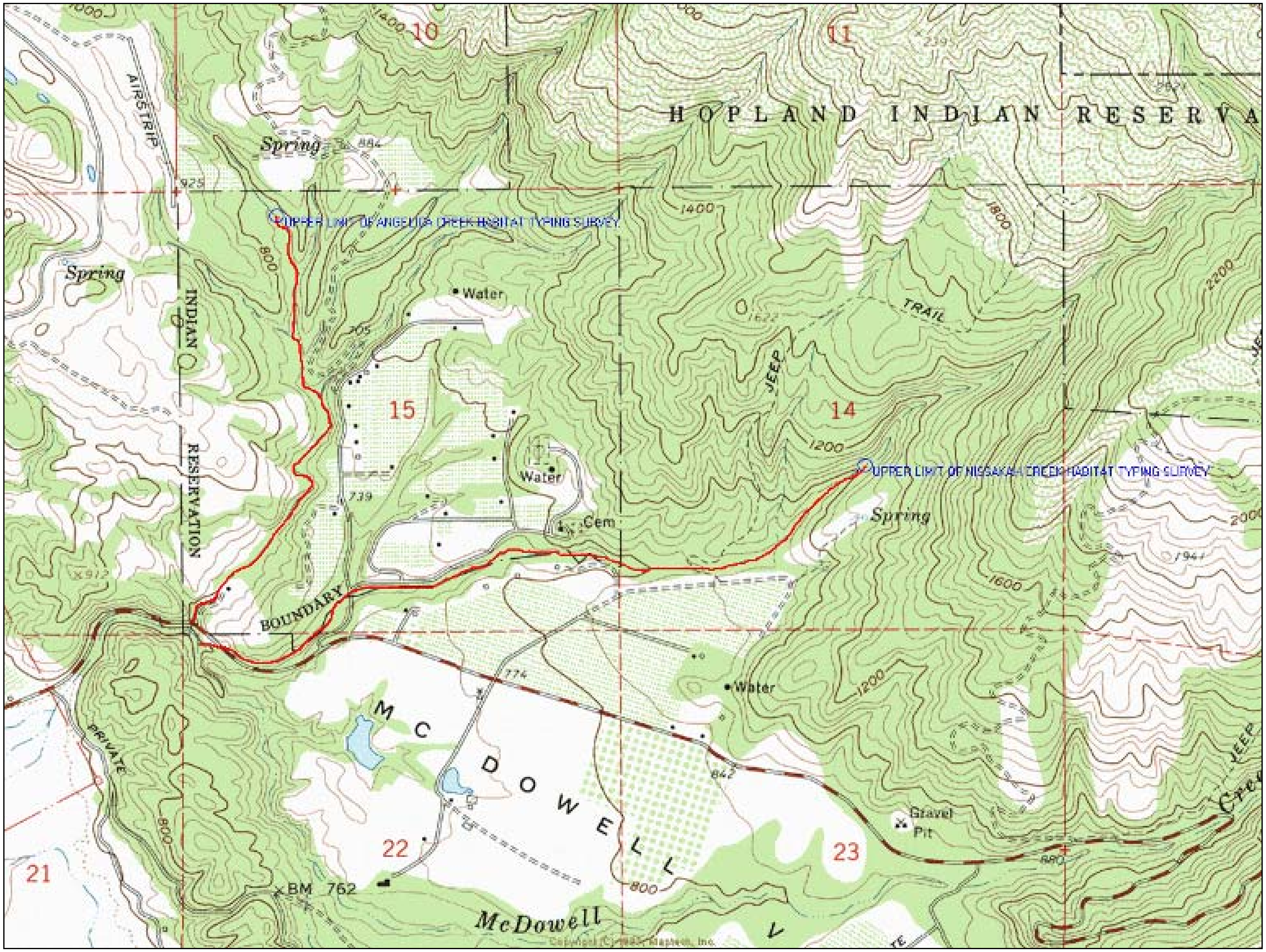


Figure 1. Location of reaches habitat-typed in Angelica and NissaKah creeks on the Hopland Reservation in Mendocino County, CA.

Results – Watershed Description of NissaKah Creek

NissaKah Creek is a second-order stream with a drainage area of approximately 2.0 square miles. Watershed elevations are approximately 700’ at the mouth to 2,800’ at the headwaters. The confluence of NissaKah Creek and McDowell Creek is located approximately 250 feet upstream of the mouth of Angelica Creek (Figure 1). Just over 11,000 feet of NissaKah Creek’s main channel was habitat-typed as delineated by the red line in Figure 1. The NissaKah Creek habitat typing survey was terminated within a reach with a slope greater than 7%, which was upstream of a reach with a slope greater than 13%. This steep reach was dominated by plunge pools over large boulders and bedrock (Figure 2).

Figure 2. Plunge pool (Unit #304) on upper NissaKah Creek with a drop of approximately six to seven feet. No fish were observed upstream of this pool.

Results – Channel Type Classifications in Angelica Creek

The channel type classification scheme presented in the CDFG Restoration Manual is a modified version of the Rosgen classification method (Rosgen 1994 and 1996). The minimum length of a channel type is equal to 20 bank-full widths. Channel types are usually classified by the following eight morphological features:

1. Channel width.
2. Depth.
3. Velocity.
4. Discharge.
5. Channel slope.
6. Roughness of channel-bed substrate.
7. Sediment load.
8. Dominant sediment particle size.

Some applications of channel type classification data include:

- Determine the suitability of various types of in-stream restoration structures.
- Describe specific stream reaches by channel type and sequence within a watershed.
- Predict a stream's behavior from its appearance.
- Describe the condition of the stream and its ability to transport sediment yield from the watershed.
- Provide a consistent and reproducible frame of reference for communication among those working with river systems and watershed restoration planning.

In classifying channel types, the following criteria were derived from the features listed above:

1. Channel entrenchment
2. Width to depth ratio.
3. Sinuosity.
4. Channel slope.
5. Dominant sediment particle size at velocity crossover areas.

In Angelica Creek, four channel types were identified:

1. Mouth through Unit #041 (1,674' reach) = **F-3** channel type. Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio, predominantly cobble substrate. F-3 channels are good for bank-placed boulders; single and opposing wing deflectors. F-3 channels are fair for plunge weirs; boulder clusters; channel constrictors and log cover.

2. Unit #042 – Unit #061 (413' reach) = **G-1** channel type. Entrenched "gully" step-pool and low width/depth ratio on moderate gradient and stable within a bedrock controlled channel. G-1 channels are fair for log cover and poor for boulder clusters.

3. Unit #062 up to the Pratt Ranch culvert (2,047' reach) = **F-3** channel type. See description above.

4. Upstream side of road crossing to end of survey (2,650' reach) = **F-4** channel type. Entrenched meandering riffle/pool channel on low gradient with high width/depth ratio and predominantly gravel substrate. F-4 channels are good for bank-placed boulders, fair for plunge weirs and log cover, and poor for boulder clusters.

Results - Habitat Type Distribution in Angelica Creek

In Angelica Creek, 271 (Level IV) habitat units were identified within 6,791 feet of channel. At Level II, by occurrence, riffles were most abundant, comprising 131 units (48.3% of the 271 units). At Level II, by occurrence, pools were the second most abundant type of habitat identified, comprising 112 units (41.7% of the 271 units). At Level II, 27 flat-water habitat units were identified (10% of the 271 units). One culvert, located underneath Pratt Ranch Road, was an additional habitat type designated during the Angelica Creek survey.

At Level II, by total length, riffles comprised 3,992 feet (58.8%) of the surveyed reach. At Level II, by total length, pools comprised 2,113 feet (31.1%) of the surveyed reach. At Level II, flat-water habitat units comprised 686 feet (10.1%) of the surveyed reach.

A total of 112 pools were identified in Angelica Creek and most (65) pools were formed by scour (Table 2). At a Level IV category, mid-channel pools were the most common type of pool (Table 2). Overall, the pools were shallow with an average maximum depth of 1.2 feet. Only nine pools had maximum depths greater than two feet, of which one pool had a maximum depth greater than three feet. For first and second order streams, CDFG has defined a primary pool as having a maximum depth greater than two feet. CDFG also determined that first and second order streams should have at least 40% of their pools meeting the primary pool definition. Angelica Creek's total number of nine primary pools comprised only 8% of all pool habitats.

The total surface areas of Level II habitat types were calculated by multiplying total lengths by the average wetted widths. There was 12,678 ft^2 of pools (35%), 19,960 ft^2 of riffles (55%) and 3,567 ft^2 of flat-water habitats (10%). CDFG has determined that first and second order streams should have at least 50% of their wetted surface area comprised of pool habitats; 35% of Angelica Creek's wetted surface area was comprised of pool habitats.

Table 2. Pool types identified during the Angelica Creek habitat typing survey.

LEVEL II	LEVEL III	LEVEL IV
113 POOLS	45 MAIN CHANNEL POOLS	3 Trench Pools (TRP)
		41 Mid-Channel Pools (MCP)
		1 Channel Confluence Pool (CCP)
	65 SCOUR POOLS	12 Corner Pools (CRP)
		1 Lateral Scour Pool – Log (LSL)
		6 Lat. Scour Pools – Root Wad (LSR)
		7 Lat. Scour Pools – Bedrock (LSBk)
		11 Lat. Scour Pools – Boulder (LSBo)
		18 Lat. Scour Pools – Bank (LSBank)
		10 Plunge Pools (PLP)
	2 BACKWATER POOLS	1 Backwater Pool – Boulder (BPB)
		1 Dammed Pool (DPL)

Shelter rating values were calculated by multiplying the shelter value by the percentage of the habitat unit covered. Shelter values greater than 80 are considered "fair" and values exceeding 100 are considered indicators of "good" habitat. In Angelica Creek the 112 pools had an average shelter rating of 24.6, with 14 pools having a score of at least 80 and only five pools having shelter rating scores ≥100. One mid-channel pool (Unit #88) had a shelter rating of 120. In pools, boulders were the most common shelter type, followed by terrestrial vegetation and the root masses of terrestrial vegetation. Large woody debris was a minor component of habitat complexity in Angelica Creek and was observed in only 21 of the 112 pools identified.

Results - Spawning Substrate Availability in Angelica Creek

Suitable spawning substrate was observed throughout the survey in 67 specific locations, mostly in pool-tails (64 locations) and in the tail-outs of three flat-water habitats. Approximately 756 ft^2 of suitable spawning habitat was recorded for the 6,791' of surveyed stream channel.

Embeddedness values ranged from a low of 2.8 to a high of 3.6, with an average of 3.2. CDFG considers embeddedness values between 2.0 and 3.0 to be of fair (and declining) quality and values greater than 3.0 indicative of poor-quality spawning substrate due to excessive levels of fine sediments.

Results - Stream Bank Composition and Dominant Vegetation in Angelica Creek

The CDFG habitat typing protocol characterizes the dominant stream bank composition of both banks within each habitat unit as bedrock, boulder, cobble/gravel, or silt/clay/sand for the first 20 feet of bank, starting at the bank-full channel margin. In many cases these 20-foot widths were comprised of several substrate types, however only the dominant type was recorded on the data sheet. Silt/sand/clay was the most common substrate composition of Angelica Creek's banks, and was noted along the left-bank of 240 habitat units and along the right-bank of 215 habitat units. The second-most common dominant stream-bank substrate was cobble/gravel, as noted along the left-bank of 20 habitat units and along the right-bank of 39 habitat units. Bedrock was the third-most common dominant stream-bank substrate type and was noted along the left-bank of eight habitat units and along the right-bank of 15 habitat units. The least common dominant stream-bank substrate type was boulder, as noted along the left-bank of only two habitat units and along the right-bank of only one habitat unit.

The CDFG habitat typing protocol characterizes the dominant stream bank vegetation composition within each habitat unit as grass, brush, deciduous trees, coniferous trees, or no vegetation for the first 20 feet of bank; starting at the bank-full channel margin. In many cases this 20-foot width was comprised of several vegetation types, however only the dominant type was recorded on the data sheet. The surveyor following the CDFG protocol must also visually estimate the total amount of the 20-foot wide bank area that is covered with all vegetation types.

Brush was the most common dominant vegetation type on Angelica Creek's banks, and was noted along the left-bank of 174 habitat units and along the right-bank of 150 habitat units. The second-most common dominant vegetation type was deciduous trees, as noted along the left-bank of 50 habitat units and along the right-bank of 77 habitat units. Grass was the third-most common dominant vegetation type and was noted along the left-bank of 42 habitat units and along the right-bank of 40 habitat units. No vegetation was noted along the left-bank of three habitat units and along the right-bank of four habitat units. Coniferous trees were uncommon and were not selected as the dominant vegetation type along the surveyed reach of Angelica Creek.

The percentage of the 20-foot width of stream bank covered by all vegetation types in Angelica Creek was approximately 60% along the left-bank and approximately 50% along the right-bank. This visual estimate was lower than the ≥65% coverage recommended by CDFG as an indicator of good-quality habitat; however the Angelica Creek survey was conducted in April just as most plant and tree species were just starting to grow or come out of dormancy. RTA assumes that this coverage would be above the 65% level if estimated in May through September.

Although the canopy density was not measured along Angelica Creek for the reasons listed in the Introduction, qualitatively, the canopy appeared quite dense along most of the 6,800' of assessed channel. The only reach with sparse canopy was between habitat Unit #042 and Unit #061 (413' reach), the highly entrenched bedrock controlled channel reach where one would not expect a dense riparian canopy to exist.

Results - Fish and Amphibian Observations in Angelica Creek

During the first week of habitat typing Angelica Creek (April 15th – 18th), no juvenile salmonids were observed. RTA flagged a completed steelhead redd in the tail-out of Unit #018, a plunge pool formed by a boulder weir in lower Angelica Creek. A possible redd was also observed in the tail-out of the outlet pool of the Pratt Ranch Road culvert (Unit #131), but was not flagged. Two adult steelhead were also observed in Angelica Creek on February 25th by Maura Darbro and Shawn Pady, Tribal employees. This pair of steelhead was observed approximately 2,500' up Angelica Creek in the vicinity of habitat Unit #080.

The second session of habitat typing occurred on April 28th – 30th and newly emerged young of the year (y-o-y) salmonids were observed throughout the lowermost 2,700' of stream channel. The upstream distribution was distinctly cut-off at a pool with a short, yet steep, bedrock constriction at the upper end. No fish were observed in Angelica Creek upstream of the Pratt Ranch Road culvert which was assessed in 2003 during the Russian River fish passage assessment project as a complete migration barrier due to the large drop at the outlet (Taylor 2003).

RTA also observed foothill yellow-legged frogs (*Rana boylii*) throughout the entire surveyed reach of Angelica Creek. In the reach upstream of Pratt Ranch Road, several red-legged frogs (*Rana aurora*) were observed. In several pools near the upper end of the survey, newts (not sure if these were rough-skinned or California newts) were observed in several pools. On April 30th within the channel reach between Units #42 and #61, some interesting egg masses were observed in several pools. These eggs masses were best described as long tangled strands with the eggs mostly in a single row within each strand. These were most likely the eggs of the western toad (*Bufo boreas*).

Results - Water and Shaded Air Temperatures in Angelica Creek

Water and shaded air temperatures were taken throughout each survey day, typically at the start of a new data sheet (every 10 habitat units). Because the field work was conducted in the early spring, water temperatures were well within the range of favorable conditions for anadromous salmonids, including spawning adults, incubating eggs and newly emerged fry (Table 3).

RTA assisted the Tribal EPA in starting a summer water temperature monitoring program, with the deployment of three HOBO temperature recorders in Angelica Creek. These devices were spread throughout the channel and will help in determining if certain reaches of Angelica Creek are suitable for over-summering juvenile salmonids. Additional information regarding the locations of the deployed HOBO temperature recorders is located in Appendix B.

Table 3. Shaded air and water temperatures measured in Angelica Creek in April of 2008.

DATE	TIME	SHADED AIR TEMP (^oF)	WATER TEMP (^oF)
4/15/2008	8:45 AM	48	47
4/15/2008	9:45 AM	52	49
4/15/2008	11:00 AM	62	53
4/15/2008	11:50 AM	58	53
4/15/2008	1:10 PM	66	55
4/15/2008	2:25 PM	70	58
4/15/2008	3:40 PM	68	59
4/16/2008	8:15 AM	45	46
4/16/2008	9:45 AM	47	47
4/16/2008	10:55 AM	56	49
4/16/2008	12:25 PM	65	50
4/16/2008	1:45 PM	68	56
4/16/2008	3:15 PM	72	59
4/17/2008	9:25 AM	63	50
4/17/2008	10:05 AM	65	50
4/17/2008	11:05 AM	68	52
4/17/2008	11:50 AM	66	52
4/17/2008	1:00 PM	70	57
4/17/2008	2:15 PM	76	59
4/17/2008	3:15 PM	75	59
4/17/2008	4:00 PM	69	58
4/18/2008	10:45 AM	64	51
4/18/2008	11:30 AM	65	52
4/18/2008	12:50 PM	70	55
4/18/2008	2:00 PM	75	58
4/28/2008	11:00 AM	73	55
4/29/2008	9:30 AM	59	52
4/29/2008	10:20 AM	57	53
4/29/2008	11:50 AM	60	54

Results – Channel Type Classifications in NissaKah Creek

In NissaKah Creek, four channel types were identified:

1. Mouth through Unit #237 (7,140' reach) = **F-3** channel type. Entrenched meandering riffle/pool channel on low gradients with high width/depth ratio, predominantly cobble substrate. F-3 channels are good for bank-placed boulders; single and opposing wing deflectors. F-3 channels are fair for plunge weirs; boulder clusters; channel constrictors and log cover.

2. Unit #238 - Unit #245 (1,939' reach) = **D-3** channel type. Multiple channels longitudinal and transverse bars; very wide channel with eroding banks; predominantly cobble substrate. D-3 channels are fair for bank-placed boulders, single and opposing wing-deflectors and channel constrictors. Poor for plunge weirs, boulder clusters and log cover.

3. Unit #246 – Unit #264 (437' reach) = **B-3** channel type. Moderately entrenched, moderate gradient, riffle dominated with infrequently spaced pools; very stable plan and profile; stable banks; predominantly cobble substrate. B-3 channels are good for placement of plunge weirs, boulder clusters, single and opposing wing deflectors and log cover structures.

4. Unit #265 to end of survey (1,536' reach) = **A-2** channel type. Steep, narrow, cascading, step-pool streams, high energy/debris transport associated with depositional soils; boulder dominated channel. A-2 channels are not suitable for placement of in-stream habitat improvement structures due primarily to high-energy nature of these steep channels.

Results - Habitat Type Distribution in NissaKah Creek

On NissaKah Creek 307 (Level IV) habitat units were identified within 11,052 feet of channel. Due to time constraints and remote location, the 32 uppermost habitat units (Units #276-#307) were only identified to a Level IV habitat type and lengths were measured with a hip chain.

At Level II, by occurrence, riffles were most abundant; comprising 145 units (47.2% of the 307 units). At Level II, by occurrence, pools were the second most abundant type of habitat identified, comprising 127 units (41.2% of the 271 units). At Level II, 33 flat-water habitat units were identified (8.9% of the 271 units). There were also four reaches of dry channel and two culverts identified during the NissaKah Creek habitat typing survey.

At Level II, by total length, riffles comprised 6,375 feet (57.7%) of the surveyed reach. At Level II, by total length, pools comprised 2,045 feet (18.5%) of the surveyed reach. At Level II, flat-water habitat units comprised 686 feet (7.4%) of the surveyed reach. The four sections of dry channel recorded on NissaKah Creek on April 14, 2008 equaled 1,657 feet (15%) of the surveyed channel. One of these dry sections (Unit #242) was 1,426 feet in length. The two culverts (underneath Highway 175 and Nokomis Road) totaled 155 feet of the surveyed reach.

A total of 127 pools were identified in NissaKah Creek and most (75) pools were formed by scour (Table 4). At a Level IV category, mid-channel pools were the most common type of pool (Table 4). Overall, the pools were shallow with an average maximum depth of 1.24 feet. Only seven pools had maximum depths greater than two feet, and none were deeper than three feet. NissaKah Creek's total number of seven primary pools comprised only 5.5% of all pool habitats, far below the ≥40% value recommended by CDFG for first and second order streams.

The total surface areas of Level II habitat types were calculated by multiplying total lengths by the average wetted widths. There was 12,474.5 ft^2 of pools (23%), 37,612.5 ft^2 of riffles (69%) and 4,592 ft^2 of flat-water habitats (8%). CDFG has determined that first and second order streams should have at least 50% of their wetted surface area comprised of pool habitats; 23% of NissaKah Creek's wetted surface area was comprised of pool habitats.

Table 4. Pool types identified during the NissaKah Creek habitat typing survey.

LEVEL II	LEVEL III	LEVEL IV
127 POOLS	46 MAIN CHANNEL POOLS	
		45 Mid-Channel Pools (MCP)
		1 Step Pool (STP)
	75 SCOUR POOLS	12 Corner Pools (CRP)
		7 Lat. Scour Pools – Log (LSL)
		1 Lat. Scour Pools – Root Wad (LSR)
		9 Lat. Scour Pools – Bedrock (LSBk)
		10 Lat. Scour Pools – Boulder (LSBo)
		12 Lat. Scour Pools – Bank (LSBank)
		24 Plunge Pools (PLP)
	6 BACKWATER POOLS	2 Backwater Pools – Boulder (BPB)
		1 Backwater Pools – Log (BPL)
		3 Dammed Pools (DPL)

Shelter rating values were calculated by multiplying the shelter value by the percentage of the habitat unit covered. Shelter values greater than 80 are considered "fair" and values exceeding 100 are considered indicators of "good" habitat. In NissaKah Creek, 113 of the 127 pools were rated for shelter and had an average shelter rating of 41.4. Nineteen pools had a score of at least 80 and 11 pools had shelter rating scores ≥100. One mid-channel pool (Unit #114) had a shelter rating of 210. In pools, small woody debris (logs with diameters <12") were the most common shelter type, followed by the root masses of terrestrial vegetation and then boulders. Large woody debris was a minor component of habitat complexity in NissaKah Creek and was observed in only 18 of the 113 pools rated for shelter.

Results - Spawning Substrate Availability in NissaKah Creek

Suitable spawning substrate was observed throughout the survey in 96 specific locations, mostly in pool-tails (85 locations) and in the tail-outs of 11 flat-water habitats. Approximately 1,113 ft^2 of suitable spawning habitat was recorded for the 11,052' of surveyed stream channel.

Embeddedness values ranged from a low of 2.6 to a high of 3.8, with an average of 3.0. CDFG considers embeddedness values between 2.0 and 3.0 to be of fair (and declining) quality and values greater than 3.0 indicative of poor-quality spawning substrate due to excessive levels of fine sediments.

Stream Bank Composition and Dominant Vegetation in NissaKah Creek

The CDFG habitat typing protocol characterizes the dominant stream bank composition of both banks within each habitat unit as bedrock, boulder, cobble/gravel, or silt/clay/sand for the first 20 feet of bank, starting at the bank-full channel margin. In many cases these 20-foot widths were comprised of several substrate types, however only the dominant type was recorded on the data sheet. Silt/sand/clay was the most common substrate composition of NissaKah Creek's banks, and was noted along the left-bank of 240 habitat units and along the right-bank of 215 habitat units. The second-most common dominant stream-bank substrate was cobble/gravel, as noted along the left-bank of 20 habitat units and along the right-bank of 39 habitat units. Bedrock was the third-most common dominant stream-bank substrate type and was noted along the left-bank of eight habitat units and along the right-bank of 15 habitat units. The least common dominant stream-bank substrate type was boulder, as noted along the left-bank of only two habitat units and along the right-bank of only one habitat unit.

The CDFG habitat typing protocol characterizes the dominant stream bank vegetation composition within each habitat unit as grass, brush, deciduous trees, coniferous trees, or no vegetation for the first 20 feet of bank; starting at the bank-full channel margin. In many cases this 20-foot width was comprised of several vegetation types, however only the dominant type was recorded on the data sheet. The surveyor following the CDFG protocol must also visually estimate the total amount of the 20-foot wide bank area that is covered with all vegetation types.

Brush was the most common dominant vegetation type on NissaKah Creek's banks, and was recorded along the left-bank of 174 habitat units and along the right-bank of 150 habitat units. The second-most common dominant vegetation type was deciduous trees, as noted along the left-bank of 86 habitat units and along the right-bank of 86 habitat units. Grass was the third-most common dominant vegetation type and was noted along the left-bank of 14 habitat units and along the right-bank of 29 habitat units. No vegetation was noted along the left-bank of two habitat units and along the right-bank of 11 habitat units. Coniferous trees were uncommon and were not selected as the dominant vegetation type within any of NissaKah Creek's habitat units.

The percentage of the 20-foot width of stream bank covered by all vegetation types in NissaKah Creek was approximately 68% along the left-bank and approximately 60% along the right-bank. This visual estimate (average of both banks) was slightly lower than the ≥65% coverage recommended by CDFG as an indicator of good-quality habitat; however the NissaKah Creek survey was conducted in May and April prior to most plant and tree species coming out of dormancy. RTA assumes that this coverage would be above the 65% level if estimated in May through September.

Although the canopy density was not measured along NissaKah Creek for the reasons listed in the Introduction, qualitatively, the canopy appeared quite dense along most of the 11,000' of assessed channel. The only reach with relatively sparse riparian vegetation and shading was between habitat Unit #238 and Unit #245 (1,939' reach). Most of this reach was dry during the mid-April habitat typing assessment and was characterized by multiple channels; longitudinal and transverse bars and overall a very wide channel with unstable eroding banks.

Fish and Amphibian Observations in NissaKah Creek

During the first week of habitat typing NissaKah Creek (March 11th–14th), no juvenile salmonids were observed. On March 11th, RTA flagged a completed steelhead redd in the tail-out of Unit #054, a lateral scour pool against a bedrock bank. A second redd was flagged on March 12th in the tail-out of Unit #065, a mid-channel pool with good undercut bank and exposed root masses as escape cover for adult steelhead.

On March 13th an adult female steelhead (adipose fin intact) was observed in Unit #167, a small plunge pool with under-cut bank and root mass cover. This fish would have avoided visual detection, except it was accidentally flushed out of hiding when the stadia rod was being poked around to determine the pool's maximum depth. The steelhead was visually estimated at approximately 28" – 30" in length and was definitely an un-spawned wild female.

The second session of habitat typing NissaKah Creek occurred on April 14th and newly emerged young of the year (y-o-y) salmonids were observed throughout an approximately 1,700' reach of stream channel, starting in Unit #251. These fish were observed shortly after surface water re-appeared upstream of the 1,426 foot dry reach (Unit #242). The upstream distribution of the fish observations was distinctly cut-off at Unit #304 pool, a plunge pool with a drop greater than six feet (refer back to Figure 2).

On April 29th, NissaKah Creek was walked from its mouth upstream to the location of the redd in Unit #054. Newly emerged fry were observed in a short reach (less than 300') of channel in the vicinity of the redd, with most of the fry within the lateral scour pool, suggesting that emergence was actively occurring.

In comparison to Angelica Creek, amphibian observations were more infrequent in NissaKah Creek. However, foothill yellow-legged frogs were observed sporadically throughout the entire surveyed reach of NissaKah Creek.

Water and Shaded Air Temperatures in NissaKah Creek

Water and shaded air temperatures were taken throughout each survey day, typically at the start of a new data sheet (every 10 habitat units). Because the field work was conducted in the early spring, water temperatures were well within the range of favorable conditions for anadromous salmonids, including spawning adults, incubating eggs and newly emerged fry (Table 5).

RTA assisted the Tribal EPA in starting a summer water temperature monitoring program, with the deployment of two HOBO temperature recorders in NissaKah Creek and one device in McDowell Creek just downstream of the NissaKah Creek confluence. These devices were spread throughout the channel and will help in determining if certain reaches of NissaKah Creek are suitable for over-summering juvenile salmonids.

Table 5. Shaded air and water temperatures measured in NissaKah Creek in March and April of 2008.

DATE	TIME	SHADED AIR TEMP (°F)	WATER TEMP (°F)
3/11/2008	9:00 AM	57	48
3/11/2008	10:35 AM	63	50
3/11/2008	11:40 AM	66	50
3/11/2008	12:50 PM	70	52
3/11/2008	2:10 PM	70	54
3/11/2008	3:20 PM	70	54
3/11/2008	4:30 PM	68	55
3/12/2008	9:00 AM	52	49
3/12/2008	10:20 AM	58	50
3/12/2008	11:30 AM	64	51
3/12/2008	2:10 PM	72	54
3/12/2008	3:45 PM	69	54
3/12/2008	5:00 PM	71	53
3/13/2008	9:00 AM	54	51
3/13/2008	10:15 AM	61	52
3/13/2008	11:40 AM	64	52
3/13/2008	1:15 PM	66	55
3/13/2008	2:20 PM	62	55
3/13/2008	3:50 PM	66	56
3/13/2008	4:40 PM	62	54
3/14/2008	9:30 AM	56	50
3/14/2008	11:00 AM	54	52
3/14/2008	12:00 PM	55	52
3/14/2008	1:00 PM	56	52
3/14/2008	1:50 PM	60	53
4/14/2008	11:00 AM	61	53
4/14/2008	1:00 PM	71	59
4/14/2008	2:05 PM	65	55
4/14/2008	3:30 PM	60	55

Discussion of Angelica Creek's Habitat Typing Results and Recommendations

The current habitat conditions for steelhead are marginal in Angelica Creek. These marginal conditions affect all the freshwater life-stages of steelhead and resident coastal rainbow trout.

Access for migration – There are two culverts at stream crossings that impede the upstream movement of adult spawners and rearing juveniles. The lowermost culvert is located on Highway 175 right at the stream's confluence with McDowell Creek. This culvert was assessed as a temporal barrier for all age classes of steelhead and resident coastal rainbow trout. For adult steelhead, the culvert meets passage criteria on 40% of the range of migration flows, with lack-of-depth at lower flows and excessive velocities at the upper range of flows. Resident and older juveniles had a narrow window of passage at lower flows, and then excessive velocities occur.

The second culvert is at Pratt Ranch Road and was assessed as a complete barrier due to the large drop at the outlet (Taylor et al. 2003). This county-maintained culvert is also undersized and poorly-aligned with the upstream channel, which has created a large debris jam and drop at the culvert inlet. No fish were observed in the upstream channel, which appears to have suitable spawning and rearing habitat. Twenty-eight of the 96 locations (or 29.2%) that appeared suitable for spawning were located upstream of Pratt Ranch Road. Tentatively, this upper reach may also be the only reach of Angelica Creek to have perennial flow to provide over-summering rearing habitat.

Another migration issue is in regards to the out-migration of steelhead smolts. RTA observed that the lower channel of Dooley Creek was dry by mid-April, creating a loss of connectivity to the Russian River during a time period when smolts would be out-migrating.

Spawning - There is ample spawning habitat spread throughout the 6,800 feet of surveyed channel; however most of these pool-tails are highly embedded with fine sediment. Excessive fines in spawning substrate directly affect the survival of two life stages, the incubating eggs and newly hatched alevins that are absorbing their yolk sacs, by reducing the amount of stream flow moving through the spaces between the larger substrate particles. This movement of water is necessary for providing dissolved oxygen to the developing eggs and alevins; and for removing metabolic waste products from the redd area.

Rearing – Results suggest that rearing habitat in the form of pools is limited within Angelica Creek. The contribution of pools on a percent-occurrence, percent total length and percent of area were all below the threshold values developed by CDFG to identify "good" habitat. Also, the quality of the existing pools was poor in terms of numbers of primary pools and the shelter rating values.

Discussions with several Tribal members indicated that most, if not all, of Angelica Creek's channel goes dry during the summer months. The reach downstream of the Pratt Ranch Road culvert was identified as a reach that would most likely be dry by late June or early July. RTA failed to observe any older age classes of salmonids during the habitat typing surveys, which would support this contention. Because steelhead require one to two years of rearing in freshwater prior to smolting and out-migrating, the lack of perennial flow could be a major limiting factor to Angelica Creek supporting a viable steelhead population. The Tribal EPA staff will have one employee monitoring flow and water quality throughout the summer of 2008 to identify if, and where, perennial flow exists in Angelica Creek.

Recommendations – The following list of actions should be considered in developing a strategy for improving habitat conditions for steelhead and resident coastal rainbow trout in Angelica Creek.

1. During the summer, spot-check creek to determine when and where reaches go dry. Determine if certain reaches support perennial flow, or at least isolated pools, throughout the dry season.

2. Monitor summer water temperature and dissolved oxygen in wetted reaches to determine if (and where) conditions could support over-summer rearing of juvenile steelhead.

3. If upper reach of Angelica Creek meets the above conditions, work with Mendocino County's Department of Transportation to address migration barrier at the Pratt Ranch Road culvert. This may be the highest priority restoration activity if the upper channel is capable of supporting the over-summer rearing of juvenile and/or resident salmonids.

4. Consider capturing juvenile steelhead from drying-up lower reaches and relocating them to habitat upstream of Pratt Ranch Road.

5. Examine water use within watershed and determine if pumping from creek is occurring and, if so, how much water is being extracted. If water withdrawals are an issue, explore options to provide water through other means.

6. Improve spawning habitat and pool depths by identifying sources and causes of erosion within the watershed. Develop a program to address the significant erosion sources that are treatable.

7. Improve pool rearing habitat with instream structures.

8. Continue public outreach and education to Tribal members and non-Tribal members who live within the watershed.

Discussion of NissaKah Creek's Habitat Typing Results and Recommendations

The current habitat conditions for steelhead are marginal in NissaKah Creek. These marginal conditions affect all the freshwater life-stages of steelhead and resident coastal rainbow trout.

Access for migration – There are two culverts at stream crossings that impede the upstream movement of adult spawners and rearing juveniles. The lowermost culvert is located on Highway 175 approximately 550 feet upstream from the stream's confluence with McDowell Creek. This box culvert was assessed as a temporal barrier for all age classes of steelhead and resident coastal rainbow trout. For adult steelhead, the culvert meets passage criteria on 56% of the range of migration flows, with lack-of-depth present at lower flows. This culvert was assessed as a complete barrier for resident trout and juvenile steelhead age classes due to excessive velocities.

The second culvert is at Nokomis Road and was assessed as a complete barrier (failing to meet fish passage criteria) due to the large drop at the outlet that spills over rip rap (Figure 3). Surprisingly, an adult steelhead was observed upstream of this culvert on March 13, 2008. Fifty-four of the 85 locations (or 63.5%) that appeared suitable for spawning were located upstream of Nokomis Road. Currently, a treatment of this migration barrier is being designed by Winzler and Kelly and Michael Love and Associates for the Tribal EPA Department.

The nearly 2,000-foot reach of NissaKah Creek between Units #238 - #245 was dry in late-April and appeared over-burdened with sediment and impacted by two low-water ford crossings. Juvenile salmonids were observed upstream of this reach and may be the progeny of resident coastal rainbow trout since it is unknown if passage to the upper watershed was possible for steelhead. The reach above the dry section may also be the only reach of NissaKah Creek to have perennial flow capable of providing over-summering rearing habitat.

Steelhead smolts migrating out of NissaKah Creek would also be affected by the loss of connectivity of Dooley Creek with the Russian River during a time period when smolts would be out-migrating.

Spawning - There is ample spawning habitat spread throughout the 11,000 feet of surveyed channel; however most of these pool-tails are highly embedded with fine sediment. Excessive fines in spawning substrate directly affect the survival of two life stages, the incubating eggs and newly hatched alevins that are absorbing their yolk sacs, by reducing the amount of stream flow moving through the spaces between the larger substrate particles. This movement of water is necessary for providing dissolved oxygen to the developing eggs and alevins; and for removing metabolic waste products from the redd area.

Rearing – Results suggest that rearing habitat in the form of pools is limited within NissaKah Creek. The contribution of pools on a percent-occurrence, percent total length and percent of area were all below the threshold values developed by CDFG to identify "good" habitat. Also, the quality of the existing pools was poor in terms of numbers of primary pools and the shelter rating values. In NissaKah Creek, the average shelter rating of 41.4 for pools was approximately 30% greater than the Angelica Creek average shelter rating, but still a low value.

Figure 3. Rising flows on NissaKah Creek through the Nokomis road box culvert on January 31, 2008. Photos taken by Michael Love.

As with Angelica Creek, it appears that most, if not all, of NissaKah Creek's channel goes dry during the summer months. Because steelhead require one to two years of rearing in freshwater prior to smolting and out-migrating, the lack of perennial flow could be a major limiting factor to NissaKah Creek supporting a viable steelhead population. The Tribal EPA staff will have one employee monitoring flow and water quality throughout the summer of 2008 to identify if, and where, perennial flow exists in NissaKah Creek.

Recommendations – The following list of actions should be considered in developing a strategy for improving habitat conditions for steelhead and resident coastal rainbow trout in NissaKah Creek.

1. During the summer, spot-check creek to determine when and where reaches go dry. Determine if certain reaches support perennial flow, or at least isolated pools, throughout the dry season.

2. Monitor summer water temperature and dissolved oxygen in wetted reaches to determine if (and where) conditions could support over-summer rearing of juvenile steelhead.

3. Secure funding to implement the treatment designed for the County-maintained culvert on NissaKah Creek at Nokomis Road. This may be the highest priority restoration activity if the upper channel is capable of supporting over-summer rearing of juvenile and/or resident salmonids.

4. Secure funding to design a treatment for improving fish passage through the Highway 175 box culvert on lower NissaKah Creek.

5. Examine options for purchasing the Gummer property along upper NissaKah Creek since this area supports the best rearing habitat in the watershed, as well as erosion sources in need of treatment (i.e. unpaved roads at both fords).

6. Consider capturing juvenile steelhead from drying-up lower reaches and relocating them to habitat in the upstream reaches (channel types B-3 and A-2).

7. Examine water use within watershed and determine if pumping from creek is occurring and, if so, how much water is being extracted. If water withdrawals are an issue, explore options to provide water through other means.

8. Improve spawning habitat and pool depths by identifying sources and causes of erosion within the watershed. Develop a program to address the significant erosion sources that are treatable.

9. Improve pool rearing habitat with instream structures.

10. Continue public outreach and education to Tribal members and non-Tribal members who live within the watershed.

LITERATURE CITED

Flosi, G. and F.L. Reynolds. 1994. California salmonid stream habitat restoration manual. Inland Fisheries Division, CDFG, Sacramento, California.

Rosgen, D.L. 1994. A classification of natural rivers. Catena, Volume 22: 169-199. Elsevier Science, B.V. Amsterdam.

Rosgen, D.L. 1996. Applied river morphology. Printed Media Companies, Minneapolis, Minnesota.

Taylor, R.N., T.D. Grey, A.L. Knoche, M. Love. 2003. Russian River stream crossing inventory and fish passage evaluation. Final Report, CDFG Agreement # P0030473. 79 p and appendices.

APPENEDIX A:

MODIFIED CDFG HABITAT TYPING FORM

Date__________Stream Name________________________Trib to____________________________

Surveyors______________________Lat_______________________Long______________________

Start Time______________Air Temp__________________Water Temp_______________________

Hab. Unit #										
Habitat Type										
Sd Ch.Type										
Unit Length										
Mean Width										
Mean Depth										
Max Depth										
TWC Depth										
TWC Embed										
TWC Subst.										
Area of Sub.										
ShelterValue										
% UnitCover										
% U/C Bank										
% SWD<12”										
% LWD>12”										
% Root Mass										
% Terr. Veg.										
% Aqua. Veg										
% Bubble										
%Boulder										
Substrate Composition – select two most dominant composition										
Silt-clay										
Sand										
Gravel										
Sm Cobble										
Lg Cobble										
Boulder										
Bedrock										
Bank Composition and Vegetation – see types listed below										
RB Bk Comp										
RB DomVeg										
%RB Veget.										
LB Bk Comp										
LB DomVeg										
%LB Veget.										
Comments										

Bank Comp: 1 = Bedrock 2 = Boulder 3 = Cobble/gravel 4 = Silt/clay/sand
Veg Types: 5 = Grass 6 = Brush 7 = Deciduous trees 8 = Coniferous trees 9 = No vegetation

APPENEDIX B:

LOCATIONS OF HOBO THERMOGRAPH RECORDERS IN NISSKAH AND ANGELICA CREEKS

Hopland Band of Pomo Indians - HOBO Temperature Recorder Locations

Deployment Date	Stream Name	HOBO Serial Number	Latitude	Longitude	Location Description
4/30/08	McDowell Creek	#1269100	N38.97791	W123.06421	In pool just downstream of the confluence of NissaKah Creek – under cluster of small boulders and large cobbles.
4/18/08	NissaKah Creek #1	#1269121	N38.97994	W123.05498	In pool (habitat unit #120) at upper end of rip-rapped section along East Side Rancheria Rd. Underneath large boulder on right-bank side of the channel.
4/30/08	NissaKah Creek #2	#1269097	N38.98050	W123.04858	In plunge pool (habitat unit #211) upstream of pump w/electrical wiring. HOBO underneath RB root-mass and covered w/small boulders and large cobbles.
	NissaKah Creek #3				Not yet deployed – ideally should be located at the confluence pool on Gummer's property – near habitat unit #264.
4/30/08	Angelica Creek #1	#1269111	N38.98190	W123.06079	Within bedrock reach in deepest pool – habitat unit #050. Underneath bedrock ledge covered with small boulders/large cobbles.
4/30/08	Angelica Creek #2	#1269112	N38.98906	W123.06033	Upstream of Feliz water intake in lateral scour pool – no cover in pool. HOBO covered with several small boulders/large cobbles.
4/30/08	Angelica Creek #3	#1269103	N38.99089	W123.06070	In lateral scour pool (habitat unit #214) underneath boulder and root mass. HOBO covered with several small boulders/large cobbles.
	Tributary to Angelica Creek				Downstream of Savoy's pond – not yet deployed.

HOBO temperature recording devices were placed in a protective case made from a short length of white PVC tube with an end cap. A hole was drilled in the end cap and a length of nylon twine was tied to the HOBO, threaded through the hole and tied-off to one of the rocks holding the HOBO to the creek bottom. The PVC case was hidden by stacking rocks on top of it and, if feasible, was tucked under protective cover within a pool. Each location was also flagged with a piece of unmarked yellow survey tape.

0199307001.11004

Alternatives Analysis for Nissa-kah Creek Crossing at Highway 175 Hopland, California

Prepared for:
Hopland Band of the Pomo Indians

Prepared by:

WINZLER & KELLY

ALTERNATIVES ANALYSIS FOR NISSA-KAH CREEK CROSSING AT HIGHWAY 175 HOPLAND, CALIFORNIA

Prepared for:
Hopland Band of Pomo Indians
3000 Shanel Road, P.O. Box 610
Hopland, CA 95449

Prepared by:

Steven Allen, P.E.

Winzler & Kelly
633 Third Street, Eureka, CA 95501
(707) 443-8326

REGISTERED PROFESSIONAL ENGINEER
STEVEN A. ALLEN
No. 62021
Exp. 9-30-11
CIVIL
STATE OF CALIFORNIA

NOVEMBER 2009

TABLE OF CONTENTS

TABLES

Page

FIGURES

Page

APPENDICES

1 PROJECT DESCRIPTION

Winzler & Kelly and Michael Love & Associates (MLA) have been contracted by the Hopland Band of the Pomo Indians to design fish passage improvements for Nissa-kah Creek. The project is funded through a grant from the US Fish and Wildlife Service Tribal Wildlife Grants Program.

This report presents the conceptual design alternatives for the Nissa-Kah Creek and Highway 175 culvert crossing. The crossing is located near Hopland, California in the proximity of mile marker 332, approximately 38.977438^{o} Latitude, -123.062957^{o} Longitude.

2 EXISTING CONDTIONS

2.1 Stream Crossing

The crossing consists of a single concrete box culvert. The culvert is 5.5 feet tall, 6 feet wide and approximately 56 feet long with a 1.38% slope. The culvert was constructed in 1919 and is owned and maintained by Caltrans.

Figure 1: Culvert Inlet

Figure 2: Culvert Outlet

The Nissa-Kah Creek headwaters are located in the mountains east of Hopland, California in the northeast corner of Mendocino County. Upstream of the crossing, Nissa-Kah Creek, traverses mountainous terrain, agricultural land, and some light development. The drainage area is approximately 2.4 square miles. Downstream of the crossing, Nissa-Kah creek traverses more agricultural lands (primarily vineyards) before its confluence with the Russian River (approximately 3 miles downstream).

Ross Taylor & Associates (RTA) assessed fish passage conditions at the culvert (Appendix A). The RTA assessment and FishXing modeling results indicate the following with respect to fish passage.

- Nissa-Kah Creek is an anadromous fish bearing stream.

- The culvert fails to meet some CDFG and the National Oceanic and Atmospheric Administration (NOAA) Fisheries criteria for fish passage, primarily depth and velocity criteria.

    - Juvenile: depth and velocity at all fish passage flows
    - Adult non-anadromous: depth at all flows and velocity above 3.52 cfs
    - Adult anadromous: depth below 58.21 cfs and velocity above 11.89 cfs

The FishXing modeling results indicate the following with respect to the culvert's storm capacity.

- The culvert is undersized
    - The headwater to culvert depth (HW/D) ratio equals one at approximately 190 cfs, which is less than the two year storm event (227 cfs).

    - The road is overtopped at approximately 554 cfs, which is slightly more than the ten year storm event (515 cfs).

Sheet C1 (Appendix B) of the plan set provides flow conditions, spatial information, and other existing condition data.

2.2 Upstream Channel

Immediately upstream of the culvert, the creek makes a 90 degree turn. The channel upstream of the turn has a steep bank on river right and riparian on river left. As seen in Figure 1 (above), the riparian habitat has encroached on the culvert inlet. The steep bank on river right quickly climbs 70 feet above the creek.

Surface bed material is primarily gravel and small cobble. Bedrock is visible on both banks and within the creek. Due to the limited capacity of the culvert, water regularly backs up at the culvert inlet.

2.3 Downstream Channel

The downstream channel shows moderate signs of incision. Bedrock is present on river right immediately downstream of the culvert with a point bar and upper/middle terrace at the hard bend approximately 70 feet downstream of the culvert outlet. A low terrace is located on river left downstream of the culvert. The terrace continues until the hard bend and is replaced by a steep bank.

3 DESIGN GOALS, OBJECTIVES, AND CONSTRAINTS

The primary design goal and project objective is to improve passage through the Nissa-Kah Creek and Highway 175 culvert for all age classes of steelhead/rainbow trout while leaving the existing culvert in place. No political or land use specific site constraints were expressed or considered. The project should not create modification that will cause a head cut to move upstream. Any culvert replacement projects must meet CDFG fish passage criteria. Culvert modifications are not necessarily held to all the same criteria, but any modifications should use the CDFG fish passage criteria as the project goal. Because the culvert is currently undersized, the project should minimize any additional loss of capacity.

A project initiation meeting was held on January 31, 2008 at Tribal offices. The meeting was intended to facilitate project coordination and define project objectives and constraints. In attendance were Tribal representatives, project engineers from Winzler and Kelly and Michael Love & Associates, Ross Taylor serving as the project's fisheries biologist, and staff from Mendocino Department of Transportation, CalTrans, NOAA Fisheries, and California Department of Fish and Game (CDFG). The group discussed development of a design that involved retrofitting the existing culvert and adding grade control to reduce or eliminate the drop across the outlet apron.

4 HYDROLOGIC ANALYSIS AND DESIGN FLOWS

Nissa-Kah Creek is a tributary to the Russian River. Highway 175 crosses Nissa-Kah Creek approximately 3 miles upstream the Russian River confluence. The contributing drainage area above the stream crossing is approximately 2.4 square miles. On average, the watershed receives approximately 40 inches of precipitation per year, with most of it in the form of rainfall.

4.1 Hydrology and Project Design Flows

Two standard methods were used to estimate peak flows and associated return periods for Nissa-Kah Creek: regional regression equations and a drainage area weighted statistical analysis from gaged streamflow data. Methods are summarized below and results are presented in Table 1 and calculations are included in Appendix C.

1. Flow estimates using regional regression equations developed for the North Coast Region of California by the USGS (Waananen and Crippen, 1977) were used to predict the 2, 25, 50, and 100-year return period flows. Mean annual precipitation was obtained from Parameter-elevation Regressions on Independent Slopes Model (PRISM) data layer provided by the NRCS.

2. Peak flows associated with the 1.2, 1.5, 2, 25, 50, and 100-year recurrence intervals were estimated for five local stream gages using a Log-Pearson type III (LP3) distribution as described in USGS Bulletin 17B - Guidelines for Determining Flood Flow Frequency (1982). This technique utilizes stream flow records from gaged sites and estimates the discharge in an ungaged stream through scaling by the differences in drainage area.

Table 1: Summary of Peak Flow Calculations for Nissa-Kah Creek at Hwy 175

Storm Event Q-year (cfs)		**Q-1.2**	**Q-1.5**	**Q-2**	**Q-5**	**Q-10**	**Q-25**	**Q-50**	**Q-100**
Method	USGS Regional Regression Equations	-	-	167	268	365	483	606	700
	Log Pearson Type III	111	167	227	394	515	666	780	894

Note: Drainage Area of 2.34 mi^2 and Mean Annual Precipitation of 40 inches/year

For this study, the Log Pearson Type III values are utilized.

4.2 Fish Passage Design Flows

Both the CDFG and NOAA Fisheries have fish passage design guidelines for stream crossings (CDFG, 2002; NMFS, 2001). The guidelines were developed jointly by the two agencies and are functionally equivalent. As part of the guidelines, they prescribe lower and upper fish passage design flows for adult and juvenile salmon and steelhead. Additionally, CDFG provides guidance for determining design flows for resident rainbow trout and coastal cutthroat trout. Between these lower and upper design flows water velocity and depth criteria should be met to provide unimpeded upstream passage for culvert replacement alternatives. Any modification of the existing culvert should use these criteria as the design goal.

Design criteria for fish passage flows are reported in terms of exceedance flows (the average percent of time a flow is equaled or exceeded annually) and are obtained from annual flow duration curves. Table 2 lists the design flow criteria applicable to the Nissa-Kah Creek crossing.

Exceedance flows for the project site were estimated using flow duration curves from five nearby gaged streams: A tributary to Soda Creek, Adobe Creek, Highland Creek, Dry Creek, and Goforth Creek. Scaling by drainage area was utilized to transfer the exceedance flows from the gaged streams to Nissa-Kah Creek. Table 3 lists the fish passage design flows for the project site and calculations are included in Appendix C.

Table 2: Fish Passage Design Flow Criteria

Species and Lifestage	Lower Design Flow	Upper Design Flow
Adult Anadromous	50% exceedance flow or 3 cfs (whichever is greater)	1% exceedance flow
Adult Non-Anadromous	90% exceedance flow or 2 cfs (whichever is greater)	5% exceedance flow
Juvenile Salmonids	95% exceedance flow or 1 cfs (whichever is greater)	10% exceedance flow

Table 3: Fish Passage Design Flows for Nissa-Kah Creek at Hwy 175

Species and Lifestage	Lower Fish Passage Flow	Upper Fish Passage Flow
Adult Anadromous	3.0 cfs	65.4 cfs
Adult Non-Anadromous	2.0 cfs	19.7 cfs
Juvenile Salmonids	1.0 cfs	9.4 cfs

5 DEVELOPMENT OF CONCEPTUAL FISH PASSAGE ALTERNATIVES

Several conceptual alternatives aimed at maintaining the existing grade of the upstream channel while improving fish passage conditions were initially considered. They included:

- Inner culvert modifications
- Boulder weirs

- Culvert replacement

This section summarizes each of the conceptual fish passage alternatives considered and discusses their ability to meet the project objectives and site constraints.

5.1 Inner Culvert Modifications

Evaluation of inner culvert modifications includes two approaches: utilizing baffles and an outlet sill. Baffle installation is an effective way to add roughness to a culvert, which increases water depth and decreases water velocity, but they can also reduce the culvert's hydraulic capacity. With respect to this crossing, the use of baffles was dismissed because the culvert is undersized. In addition, the Nissa-Kah creek often transports debris and baffles can entrap wood and other debris in the culvert, which further decreases the hydraulic capacity and requires additional maintenance.

Installation of an outlet sill will not affect the capacity of most (hydraulically) inlet controlled culverts. An outlet sill is located at the outlet (or sometimes on the apron if one exists) and causes a backwater effect within the culvert. The backwater effect increases the water depth and decreases the velocity. Although the outlet sill has some capability to trap debris, the debris typically passes due to its location at the outlet. Care must be taken that the outlet sill does not create a new jump barrier at the culvert outlet. An outlet sill often requires additional tailwater control structures such as boulder weirs for this reason.

5.2 Boulder Weirs

Boulder weirs are often used as grade control features, and can also help create a backwater effect. The boulder weirs create a tailwater grade control that adds depth and slows velocity. Unlike an outlet sill, boulder weirs will develop braided flow under low flow conditions, which makes accurate construction and prediction of their backwatering elevations difficult.

5.3 Culvert Replacement

Replacing the existing culvert was initially considered as a technically feasible option, but was dropped based on cost considerations. To replace the existing culvert, a new crossing would need to span approximately 20 feet. The largest Caltrans standard single box culvert spans 14 feet. Installing a double box culvert is not feasible due to the amount of debris that could become lodged at the inlet. Therefore, instead of a box culvert, a bridge or large diameter embedded multi-plate culvert would be the most likely fish friendly choices for replacement. Full replacement was not considered further as a feasible option due to cost considerations.

5.4 Summary

Of the above described initially considered options for fish passage improvements at the Nissa-Kah and Highway 175 crossing two alternatives have been developed further. The first alternative (Alternative 1) proposes to construct a series of boulder weirs. The second alternative (Alternative 2) proposes to install an outlet sill in addition to the boulder weirs.
These two alternatives are presented in the following sections.

6 ALTERNATIVE CONCEPTUAL DESIGNS

Hydraulic designs of the Nissa-Kah Creek crossing conceptual alternatives were based on the following conditions and design parameters (Table 4 and 5):

Table 4: Fish Passage Design Flows for Nissa-Kah Creek at Hwy 175

Species and Lifestage	**Lower Fish Passage Flow**	**Upper Fish Passage Flow**
Adult Anadromous	3.0 cfs	65.4 cfs
Adult Non-Anadromous	2.0 cfs	19.7 cfs
Juvenile Salmonids	1.0 cfs	9.4 cfs

Table 5: Fish Passage Design Criteria

Species and Lifestage	**Max Velocity (ft/s) (Culvert <60 ft)**	**Min Depth (ft)**	**Culvert Entrance Jump Height (ft)**	**Boulder Weir Drop (ft)**
Adult Anadromous	**6**	0.6	**1**	**1**
Adult Non-Anadromous	**4**	0.6	**1**	**1**
Juvenile Salmonids	**1**	**0.5**	**0.5**	**1**

Note: Bold indicates that criterion meets CDFG guidelines

Although modifying existing culverts to improve fish passage do not need to meet all current CDFG design criteria, the majority of the criteria values within Table 5 do meet CDFG guidelines. The minimum depth was decreased for adult anadromous and adult non-anadromous from 1 foot to 0.6 feet and 0.67 feet to 0.6 feet, respectively. The following proposed alternatives could be designed to meet the CDFG guidelines, but likely with a reduction of hydraulic capacity, which may not be approved by Caltrans.

6.1 Alternative 1: Boulder Weirs

6.1.1 Boulder Weir Geometry and Dimensions

The proposed boulder weir dimensions have not been fully defined, but the elevation for each weir has been determined. In all there are four proposed boulder weirs, each set 1 foot lower than the proceeding in the downstream direction. The first proposed weir crest elevation is 629 feet. This weir is 20 feet downstream of the culvert outlet. Each boulder weir is separated by 20 feet.

The weir apex is oriented upstream and the weir sides slope to catch the existing grade, although the specific slope has not been determined at this time. This configuration concentrates the flow towards the center, which increases depth during low flow events and decreases channel bank erosion. Sheet A1 (Appendix B) provides additional details.

6.1.2 Analysis

The boulder weirs were modeled as sharp crested weirs. The commonly accepted equation for sharp crested weirs is

$$Q = C_d 2/3\,(2g)^{1/2}\,BH^{3/2} \qquad (1)$$

where:

Q = Unrestricted flow over sharp crested weir (cfs),
C_d= Coefficient of discharge (unitless),
B = Weir width (ft),
H = Head over weir crest (ft), and
g = Gravity (ft/s^2).

6.1.3 Summary of Hydraulic Conditions

The hydraulic conditions were predicted at the three lower and upper fish passage design flows. Results are summarized below in Table 6. In addition, Sheet A1 (Appendix B) presents headwater depths and surface elevations at different flows and the water depth at the culvert inlet and outlet for the fish passage design high and low flows.

Table 6: Alternative 2 Fish Passage Hydraulic Conditions

Species and Lifestage	Flow (cfs)	Max Velocity (ft/s)	Min Depth (ft)	Culvert Entrance Jump Height (ft)	Boulder Weir Drop (ft)
Adult Anadromous	3	0.63	0.8	0	1
	65.4	6.6	1.7	0	1
Adult Non-Anadromous	2	0.43	0.8	0	1
	19.7	2.94	1.1	0	1
Juvenile Salmonids	1	0.23	0.7	0	1
	9.4	1.66	0.9	0	1

<u>Passage Conditions for Adult Anadromous Fish</u>

Adult anadromous fish should be capable of passing this culvert even though the minimum depth is 0.8 feet during the low design flow of 3 cfs and the max velocity is 6.6 ft/s during the high design flow of 65.4 cfs. Although these values do not meet the CDFG criteria values, the culvert length distance is relatively short under both of these conditions.

<u>Passage Conditions for Adult Non-Anadromous Fish</u>

Adult non-anadromous fish should have little difficulty passing this culvert for the modeled results.

Passage Conditions for Juvenile Salmonids

The design criterion for velocity for juvenile salmonids is 1.0 ft/s. Under the current alternative design, this criterion is not met for high fish passage design flows. Juveniles may find it difficult to pass the culvert during these flows. The remaining criteria were met for this design alternative.

6.1.4 Conclusions

The proposed boulder weir alternative meets the physical site constraints and meets nearly all the CDFG and NOAA fish passage goals. Juvenile passage would not be fully addressed by this alternative. The proposed design uses a minimal amount of material resulting in a cost-effective design alternative. This proposed alternative provides stable grade control downstream of the culvert. Model results do not indicate that this alternative negatively impacts culvert capacity. However, the modeling technique over estimates the back watering affect, and therefore, the depth may be shallower and velocities may be higher than predicted. Installation of boulder weirs vary based on actual rock available for the project, site conditions, and the expertise of the contractor. For these reasons, actual hydraulic performance of the finished project can vary slightly from the intended design. The proposed boulder weir project is a technically viable design alternative, but not suggested as the best alternative for this site.

6.2 Alternative 2: Outlet Sill with Boulder Weirs

6.2.1 Outlet Sill and Boulder Weir Geometry and Dimensions

The proposed outlet sill will be installed inside the culvert outlet. The proposed sill is 1.1 X 1.1 X 6 feet, which spans the entire width of the culvert. The elevation of the outlet sill crest is 628.7 feet. The sill could be constructed with concrete or steel.

Although the outlet sill can create favorable fish passage conditions within the culvert, the outlet sill itself can create a new jump barrier. Therefore, additional tailwater control measures are required to address the jump conditions. For this design alternative, boulder weirs are utilized as the tailwater control feature.

The proposed boulder weir dimensions have not been fully defined, but the elevation for each weir has been determined. In all there are four proposed boulder weirs, each set 1 foot lower than the proceeding in the downstream direction. The first proposed weir crest elevation is 628.7 feet, which is the same elevation as the outlet sill. This weir is 20 feet downstream of the culvert outlet. Each boulder weir is also separated by 20 feet. The boulder weirs would be constructed similarly to the boulder weirs described in Alternative 1. Sheet A2 (Appendix B) provides additional details.

6.2.2 Analysis

The outlet sill and the boulder weirs were modeled as sharp crested weirs using equation (1). The model first evaluates that the depth conditions are met and then increases or decreases the boulder weir elevation so the jump criteria for the species/lifestages at the design flows are met.

6.2.3 Summary of Hydraulic Conditions

The hydraulic conditions were predicted at the three lower and upper fish passage design flows. Results are summarized below in Table 7.

Table 7: Alternative 1 Fish Passage Hydraulic Conditions

Species and Lifestage	Flow (cfs)	Max Velocity (ft/s)	Min Depth (ft)	Culvert Entrance Jump Height (ft)	Boulder Weir Drop (ft)
Adult Anadromous	3	0.77	0.6	0.1	1
	65.4	4.23	2.6	1.0	1
Adult Non-Anadromous	2	0.57	0.6	0.1	1
	19.7	2.42	1.4	0.4	1
Juvenile Salmonids	1	0.33	0.5	0.1	1
	9.4	1.61	1.0	0.3	1

Passage Conditions for Adult Anadromous Fish

Adult anadromous fish should have little difficulty passing this culvert even though the minimum depth is 0.6 feet during the low design flow of 3 cfs. Although this is slightly less than the CDFG criterion value, the travel distance is relatively short at this depth. It is also highly unlikely that 3 cfs is a flow adult anadromous fish migrate during. It is believed that these adults will be able to pass throughout their design flows under this alternative.

Passage Conditions for Adult Non-Anadromous Fish

Adult non-anadromous fish should have little difficulty passing this culvert even though the minimum depth is 0.6 feet during the low design flow of 2 cfs. Although this is slightly less than the CDFG criterion value, the travel distance is relatively short at this depth. It is believed that these adults will be able to pass throughout their design flows under this alternative.

Passage Conditions for Juvenile Salmonids

The design criterion for velocity for juvenile salmonids is 1.0 ft/s. Under the current alternative design, this criterion is not met at high fish passage design flows. Juveniles may find it difficult to pass the culvert during these flows. The remaining criteria were met for this design alternative.

6.2.4 Conclusions

The proposed outlet sill culvert modification meets the physical site constraints and meets nearly all the CDFG and NOAA fish passage goals. The proposed design utilizes a minimal amount of material resulting in a cost-effective design alternative. The proposed outlet sill with boulder weirs is a considered viable design alternative.

7 OPINION OF PROBABLE CONSTRUCTION AND PROJECT COST

An opinion of probable construction cost was developed for Alternatives 1 and 2 and are presented in Appendix D. The tables contain an itemized list of probable unit construction costs in addition to an estimating contingency. An estimating contingency accounts for material and construction cost volatility as well as the unknowns associated with the current level of design. The construction costs are based on current construction and material costs. Predicting material costs and the bidding climate when the project is bid is difficult and therefore the unit costs were not inflated or adjusted for future value.

In addition to developing opinion of probable construction costs, the opinion of probable cost associated with preparation of the final bid package, which would include final construction plans, specifications, and the construction cost estimate has also been included in Appendix D. Opinion of probable costs were also developed and presented in the table for bidding assistance and construction management. The cost associated with construction management assumes prevailing wage labor rate for onsite inspection during construction.

8 SUMMARY RECOMMENDATIONS

Both of the conceptual alternatives developed are viable. Both alternatives meet most of CDFG fish passage criteria. Both alternatives could be designed to meet all of CDFG fish passage criteria but these designs could decrease the culvert capacity, which may not be approved by Caltrans. The conditions that do not meet CDFG fish passage design criteria are still within fish capabilities and should not be considered a barrier.

Following the draft submittal of this report, comments were received from NOAA Fisheries and the Mendocino County Department of Transportation. If this project moves forward into final design, NOAA will require a variance request for exceeded passage criteria and the County has suggested a ramped sill on the leading edge of the proposed outlet sill (Alternative 2) which could discourage hang-ups of Large Woody Debris (LWD). During a subsequent design effort, considerations for these comments received should be evaluated for inclusion into the final design.

Our recommendation is to proceed with Alternative 2. Installing the outlet sill will create more reliable fish passage conditions. Utilizing boulder weirs alone can create favorable conditions, but over time boulder shifting and other physical changes could alter the weir rating curve, which may cause negative fish passage conditions or negative culvert hydraulic capacity issues. Because the crossing is owned and maintained by Caltrans, it may be preferable for Caltrans to take the lead on any subsequent design and funding pursuit efforts.

9 REFERENCES

Bates, K. 2001. *Fishway Design Guidelines for Pacific Salmon*. Working paper 1.6 9/2001 Washington Department of Fish and Wildlife.

California Department of Fish and Game (CDFG). 2002. *Culvert criteria for fish passage*. 17 pages.

Lang, Margaret, Michael Love, and Bill Trush. 2004. *Improving Stream Crossings for Fish Passage: Final Report*. Humboldt State University. Prepared for National Marine Fisheries Service.

McCuen, R.H. 1998. *Hydrologic Analysis and Design.* (2^{nd} ed.). Prentice-Hall, Inc., Upper Saddle River, N.J.

National Marine Fisheries Service (NMFS). 2001. *Guidelines for salmonid passage at stream crossings*. NMFS SW Region. 14 pages.

Waananen, A.O. and J.R. Crippen. 1977. Magnitude and Frequency of Floods in California. US Geological Survey, Water Resources Investigation 77-21, Menlo Park, CA. 96 p.

Washington Department of Fish and Wildlife (WDFW). 2003. *Design of Road Culverts for Fish Passage*. (http://wdfw.wa.gov/hab/engineer/habeng.htm#upstrm).

Appendix A
Ross Taylor & Associates Assessment

FishXing Analysis for the Highway 175 Culvert on NissaKah Creek, Hopland, CA.

On February 25, 2008 Ross Taylor and Associates (RTA) surveyed the box culvert on Highway 175 on NissaKah Creek for the purposes of conducting a fish passage assessment with FishXing. Tom Grey operated the total station and recorded data and Ross Taylor was on the stadia rod.

Location Information: Highway 175. PM = 3.31. Lat/long = N38.9778188 W123.0632541

Culvert configuration: Box culvert 5.5' H x 6'W and 52.6' long. Slope = 2.1%. Invert = smooth concrete. Inlet alignment = poor, greater than 45^o turn at inlet. Culvert appears to have been lengthened from after original construction (see photo #2).

Hydrology: drainage area = 1.96 square-miles. Culvert inlet is 100% of capacity at 228 cfs and the five-year storm is 218.7 cfs. Adult steelhead high-passage flow (1% excedence flow) = 55.8 cfs, resident trout/2+ = 17.0 cfs and juveniles = 8.4 cfs.

FishXing results: Using swim speeds of 8ft/sec and 16 ft/sec and a minimum depth of 0.5' for adult steelhead, the culvert meets criteria on 56% of the range of flows, with a lack of depth up to about 22 cfs. For resident trout and juveniles the culvert is a velocity barrier at all migration flows.

Using the CDFG Section 9 criteria (more conservative than 8ft/sec-16ft/sec-0.5'), the culvert fails to meet all adult criteria – due to excessive velocities above 9 cfs and a lack-of-depth below 50 cfs.

Photo #1: Highway 175 culvert on NissaKah Creek – looking upstream from below TWC.

Ross Taylor and Associates
(707)-839-5022
rossntaylor@sbcglobal.net

Photo #2: Highway 175 culvert on NissaKah Creek – looking upstream from outlet – note change in hydraulics at point where crossing had been lengthened from original construction.

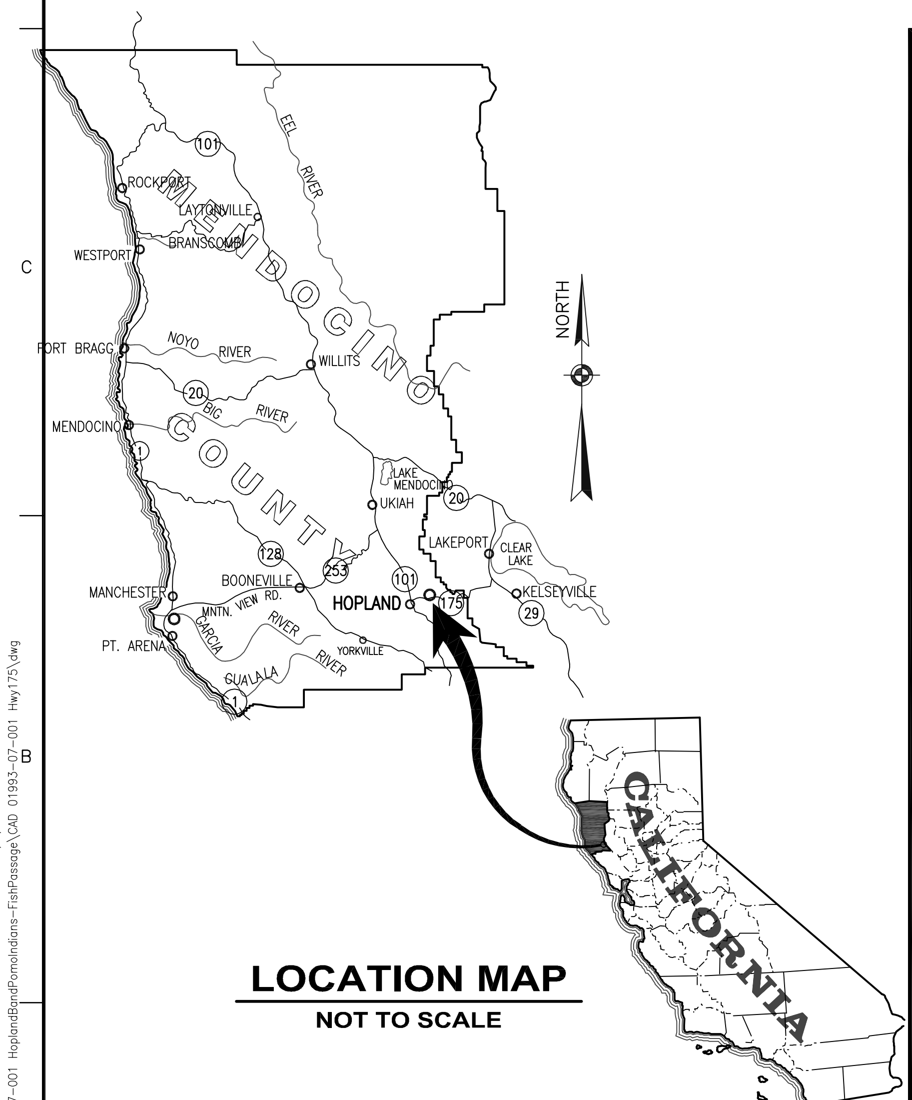
Ross Taylor and Associates
(707)-839-5022
rossntaylor@sbcglobal.net

Appendix B
Conceptual Design Plan Set

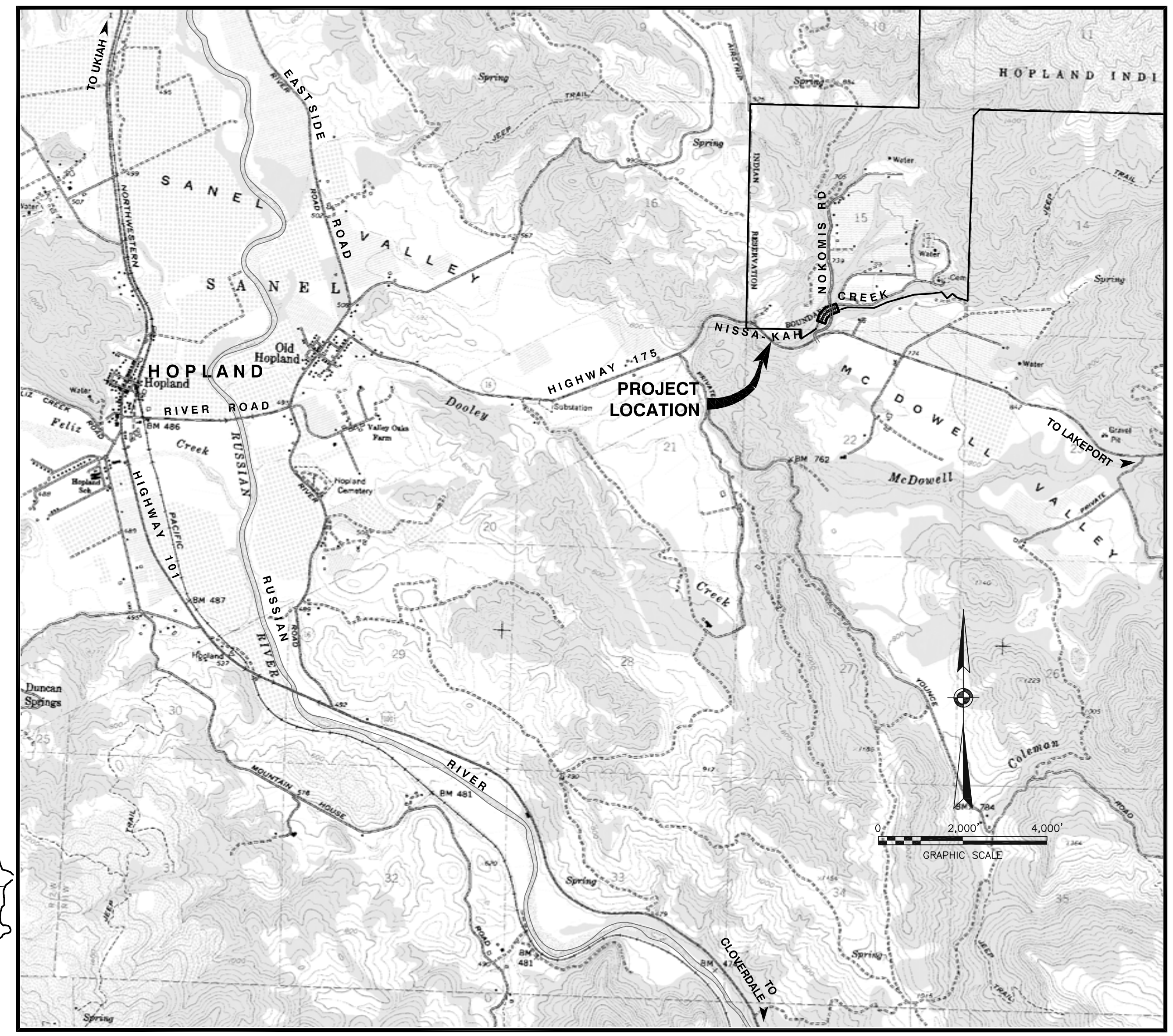
HOPLAND BAND OF POMO INDIANS

NISSA-KAH CREEK AT HWY 175
FISH PASSAGE IMPROVEMENT PROJECT
25% SUBMITTAL

NOVEMBER 2009



LOCATION MAP
NOT TO SCALE



SOURCE: USGS QUADRANGLE MAP

VICINITY MAP
SCALE: SEE SCALE BAR

SHEET INDEX

G-1	1 of 5	COVER SHEET
G-2	2 of 5	GENERAL NOTES
C-1	3 of 5	EXISTING CONDITIONS
A-1	4 of 5	ALTERNATIVE 1 BOULDER WEIRS
A-2	5 OF 5	ALTERNATIVE 2 OUTLET SILL WITH BOULDER WEIRS

REVISIONS

SYM.	DESCRIPTION	DATE	APPROVED

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT

DES | DRN | SUPV | CHK

SEE SCALE BAR

SEAL

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT HWY 175
FISH PASSAGE IMPROVEMENT PROJECT
GENERAL
COVER SHEET

JOB NUMBER 01993-07-001

SHEET 1 OF 5

G-1

12/2/2009 2:09 PM
P:\2005 & Beyond\01993 Hopland Band of Pomo Indians\01993-07-001 HoplandBandPomoIndians-FishPassage\CAD 01993-07-001 Hwy175\dwg
0199307001-Hwy175_01-G1

GENERAL:

- ℄ — CENTERLINE
- ø — DIAMETER
- ± — APPROXIMATE
- @ — AT
- △ — DELTA
- WATER SURFACE
- SECTION OR DETAIL DESIGNATION (LETTER INDICATES SECTION, NO. INDICATES DETAIL)
- A / G-2 | C-1 — SHEET WHERE SECTION OR DETAIL OCCURS; SHEET FROM WHICH SECTION OR DETAIL WAS TAKEN
- (A) — DETAIL

SYMBOLS

NEW	EXISTING	
—x—x—	—x—x—	FENCE
/// \\\	/// \\\	AC PAVEMENT
10 / 12	10 / 12	CONTOUR LINE
		TOP OF BANK
		TOE OF BANK
		DRAINAGE/CREEK/DITCH/SWALE
△ TBM		TEMPORARY BENCH MARK

ABBREVIATIONS

ESM=	ENGINEERED STREAMBED MATERIAL
(N)=	NEW
(E)=	EXISTING
APPROX.=	APPROXIMATE
RSP=	ROCK SLOPE PROTECTION
CL=	CENTERLINE
TYP=	TYPICAL
INV=	INVERT ELEVATION
TBD=	TO BE DETERMINED
W/=	WITH
EL=	ELEVATION

GENERAL NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR COMPLYING WITH ALL PROJECT PERMITS. OWNER IS RESPONSIBLE FOR OBTAINING AND PROVIDING COPIES OF ALL NECESSARY PROJECT PERMITS.
2. PRIOR TO COMMENCING ANY EXCAVATION OR DEMOLITION WORK, FISH SCREENS AND COFFER DAMS MUST BE INSTALLED AND FISH REMOVED FROM THE PROJECT AREA. CONTRACTOR SHALL COORDINATE WITH FISHERIES BIOLOGIST RESPONSIBLE FOR REMOVING FISH FOR SCHEDULING PLACEMENT OF FISH SCREENS, COFFER DAM AND DEWATERING PLAN. FISHERIES BIOLOGIST IS RESPONSIBLE FOR SITING THE BEST LOCATION FOR FISH SCREENS.
3. EXISTING VEGETATION SHALL BE PROTECTED AND LEFT UNDISTURBED AS MUCH AS PRACTICAL. EXISTING NATIVE PLANTS IN AREAS TO BE DISTURBED SHALL BE TRANSPLANTED PRIOR TO GROUND DISTURBANCE FOR REPLANTING AFTER FINAL GRADING HAS OCCURRED.
4. ALL UTILITIES SHOWN (IF ANY) WERE LOCATED FROM ABOVE GROUND VISUAL STRUCTURES. NO UTILITY RESEARCH WAS CONDUCTED FOR THIS SITE. NOTIFY UNDERGROUND SERVICE ALERT PRIOR TO ANY GRADING OR EXCAVATION WITHIN THE SITE AT 1-800-227-2600.
5. NATIVE TOPSOIL THAT IS EXCAVATED TO BE SEGREGATED AND STOCKPILED ON SITE FOR RE-USE AFTER ROUGH GRADING IS COMPLETE.
6. NATIVE STREAMBED MATERIAL THAT IS EXCAVATED SHALL BE SEGREGATED AND STOCKPILED ON SITE FOR RE-USE IN CHANNEL REGRADING.
7. UNSUITABLE EXCAVATED MATERIAL SHALL BE REMOVED FROM SITE AND DISPOSED OF IN A MANNER CONSISTENT WITH APPLICABLE REGULATIONS SUCH AS COUNTY GRADING ORDINANCES AND COASTAL GRADING PLANS. CONTRACTOR IS RESPONSIBLE FOR PROPER DISPOSAL OF UNSUITABLE MATERIALS TAKEN FROM SITE.
8. ANY PUMPS USED ON-SITE (DEWATERING ETC) SHALL BE PLACED ON ABSORBENT PADS. THE CONTRACTOR SHALL HAVE SPILL CONTAINMENT MATERIALS LOCATED AT THE SITE, WITH OPERATORS TRAINED IN SPILL CONTROL PROCEDURES.
9. PERFORM GRADING IN ACCORDANCE WITH THE LATEST EDITION OF APPENDIX CHAPTER 33 OF THE CALIFORNIA BUILDING CODE AND APPLICABLE MENDOCINO COUNTY REGULATIONS.
10. IN THE EVENT CULTURAL RESOURCES (I.E., HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES, AND HUMAN REMAINS) ARE DISCOVERED DURING GRADING OR OTHER CONSTRUCTION ACTIVITIES, WORK SHALL BE HALTED WITHIN A 100 FOOT RADIUS OF THE FIND. A QUALIFIED ARCHEOLOGIST SHALL BE CONSULTED FOR AN ON-SITE EVALUATION. ADDITIONAL MITIGATION MAY BE REQUIRED BY THE COUNTY PER THE ARCHEOLOGIST'S RECOMMENDATIONS. IF HUMAN BURIALS OR HUMAN REMAINS ARE ENCOUNTERED, THE CONTRACTOR SHALL ALSO NOTIFY THE COUNTY CORONER.
11. SHOULD GRADING OPERATIONS ENCOUNTER HAZARDOUS MATERIALS, OR WHAT APPEAR TO BE HAZARDOUS MATERIALS, STOP WORK IN THE AFFECTED AREA IMMEDIATELY AND CONTACT 911 OR THE APPROPRIATE AGENCY FOR FURTHER INSTRUCTION.

TOPOGRAPHIC SURVEY NOTES:

1. TOPOGRAPHIC DATA IS BASED ON A FIELD SURVEY CONDUCTED BY GUTIERREZ LAND SURVEYING ON FEBRUARY 27, 2008. CONTOUR INTERVAL = 1 FOOT.
2. BASIS OF ELEVATIONS: SCALED FROM QUAD MAPS. TEMPORARY BENCHMARK: FOUND 2" BRASS DISK SET BY CAL TRANS, LOCATED WEST OF NORTHERLY HEADWALL AS SHOWN HEREON. ELEVATION = 640.00.
3. BASIS OF BEARINGS: ROTATION OF THIS MAP IS BASED ON COMPASS READINGS AT THE SITE.
4. ALL UTILITIES SHOWN WERE TAKEN FROM ABOVE GROUND VISUAL STRUCTURES. NO UTILITY RESEARCH WAS CONDUCTED. NOTIFY UNDERGROUND SERVICE ALERT PRIOR TO GRADING OR EXCAVATION WITHIN THE SITE AT 1-800-227-2600

EROSION & SEDIMENT CONTROL NOTES:

1. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO MINIMIZE EROSION AND PREVENT THE TRANSPORT OF SEDIMENT TO THE ADJACENT STREAM AND SENSITIVE AREAS.
2. AT A MINIMUM, THE CONTRACTOR SHALL EMPLOY THE FOLLOWING BEST MANAGEMENT PRACTICES (BMPS) AS DESCRIBED IN THE CURRENT CALTRANS STORM WATER QUALITY HANDBOOK AS NEEDED:
   - SS-2 PRESERVATION OF EXISTING VEGETATION
   - SS-6 REDWOOD MULCH
   - SS-10 OUTLET PROTECTION/VELOCITY DISSIPATION DEVICES
   - SC-1 SILT FENCE
   - NS-2 DEWATERING OPERATIONS
   - NS-3 PAVING AND GRINDING OPERATIONS
3. IT WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO FIX ANY DEFICIENCIES INDICATED BY THE OWNER OR THE OWNERS REPRESENTATIVE.
4. PRIOR TO FINAL ACCEPTANCE ALL AREAS OF THE SITE WILL BE VEGETATED OR PERMANENTLY STABILIZED AND ALL TEMPORARY SEDIMENT CONTROL MEASURES SHALL BE REMOVED.
5. PERFORM EROSION PREVENTION AND SEDIMENT CONTROL IN ACCORDANCE WITH THE LATEST EDITION OF APPENDIX CHAPTER 33 OF THE CALIFORNIA BUILDING CODE, APPLICABLE MENDOCINO COUNTY REGULATIONS, AND SECTION 20 OF THE CALTRANS STANDARD SPECIFICATIONS.
6. THE OWNER IS RESPONSIBLE FOR OBTAINING AND COMPLYING WITH THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) GENERAL PERMIT WASTE DISCHARGE REQUIREMENTS FOR DISCHARGES OF STORM WATER RUNOFF ASSOCIATED WITH CONSTRUCTION ACTIVITY.
7. PRESERVATION OF EXISTING VEGETATION SHALL OCCUR TO THE MAXIMUM EXTENT PRACTICABLE.
8. DISCHARGES OF POTENTIAL POLLUTANTS FROM CONSTRUCTION SITES SHALL BE PREVENTED USING SOURCE CONTROLS TO THE MAXIMUM EXTENT PRACTICABLE. POTENTIAL POLLUTANTS INCLUDE BUT ARE NOT LIMITED TO: SEDIMENT, TRASH, NUTRIENTS, PATHOGENS, PETROLEUM HYDROCARBONS, METALS, CONCRETE, CEMENT, ASPHALT, LIME, PAINT, STAINS, GLUES, WOOD PRODUCTS, PESTICIDES, HERBICIDES, CHEMICALS, HAZARDOUS WASTE, SANITARY WASTE, VEHICLE OR EQUIPMENT WASH WATER AND CHLORINATED WATER.
9. WHENEVER IT IS NOT POSSIBLE TO UTILIZE EROSION PREVENTION MEASURES, EXPOSED SLOPES SHALL EMPLOY SEDIMENT CONTROL DEVICES, SUCH AS FIBER ROLLS AND SILT FENCES. FIBER ROLLS AND SILT FENCES SHALL BE TRENCHED AND KEYED INTO THE SOIL AND INSTALLED ON CONTOUR. SILT FENCES SHALL BE INSTALLED APPROXIMATELY 2 TO 5 FEET FROM TOE OF SLOPE.
10. SOIL AND MATERIAL STOCKPILES SHALL BE PROPERLY PROTECTED TO MINIMIZE SEDIMENT AND POLLUTANT TRANSPORT FROM THE CONSTRUCTION SITE.
11. SOLID WASTE, SUCH AS TRASH AND DEBRIS, SHALL BE PLACED IN DESIGNATED COLLECTION AREAS OR CONTAINERS. THE CONSTRUCTION SITE SHALL BE CLEARED OF SOLID WASTE DAILY, OR AS NECESSARY, AND REGULAR REMOVAL AND PROPER DISPOSAL SHALL BE ARRANGED.
12. PROPER APPLICATION, CLEANING AND STORAGE OF POTENTIALLY HAZARDOUS MATERIALS, SUCH AS PAINTS AND CHEMICALS, SHALL BE CONDUCTED TO PREVENT THE DISCHARGE OF POLLUTANTS.
13. WHEN UTILIZED, TEMPORARY RESTROOMS AND SANITARY FACILITIES SHALL BE LOCATED AND MAINTAINED TO PREVENT THE DISCHARGE OF POLLUTANTS.
14. APPROPRIATE VEHICLE STORAGE, FUELING, MAINTENANCE AND CLEANING AREAS SHALL BE DESIGNATED AND MAINTAINED TO PREVENT DISCHARGE OF POLLUTANTS.
15. NY FUEL DRIVEN PUMPS USED ON-SITE (DEWATERING ETC) SHALL BE PLACED ON ABSORBENT PADS. THE CONTRACTOR SHALL HAVE SPILL CONTAINMENT MATERIALS LOCATED AT THE SITE, WITH OPERATORS TRAINED IN SPILL CONTROL PROCEDURES.

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT

DES PTJ | DRN PTJ | SUPV SAA | CHK SAA

SEE SCALE BAR

SEAL

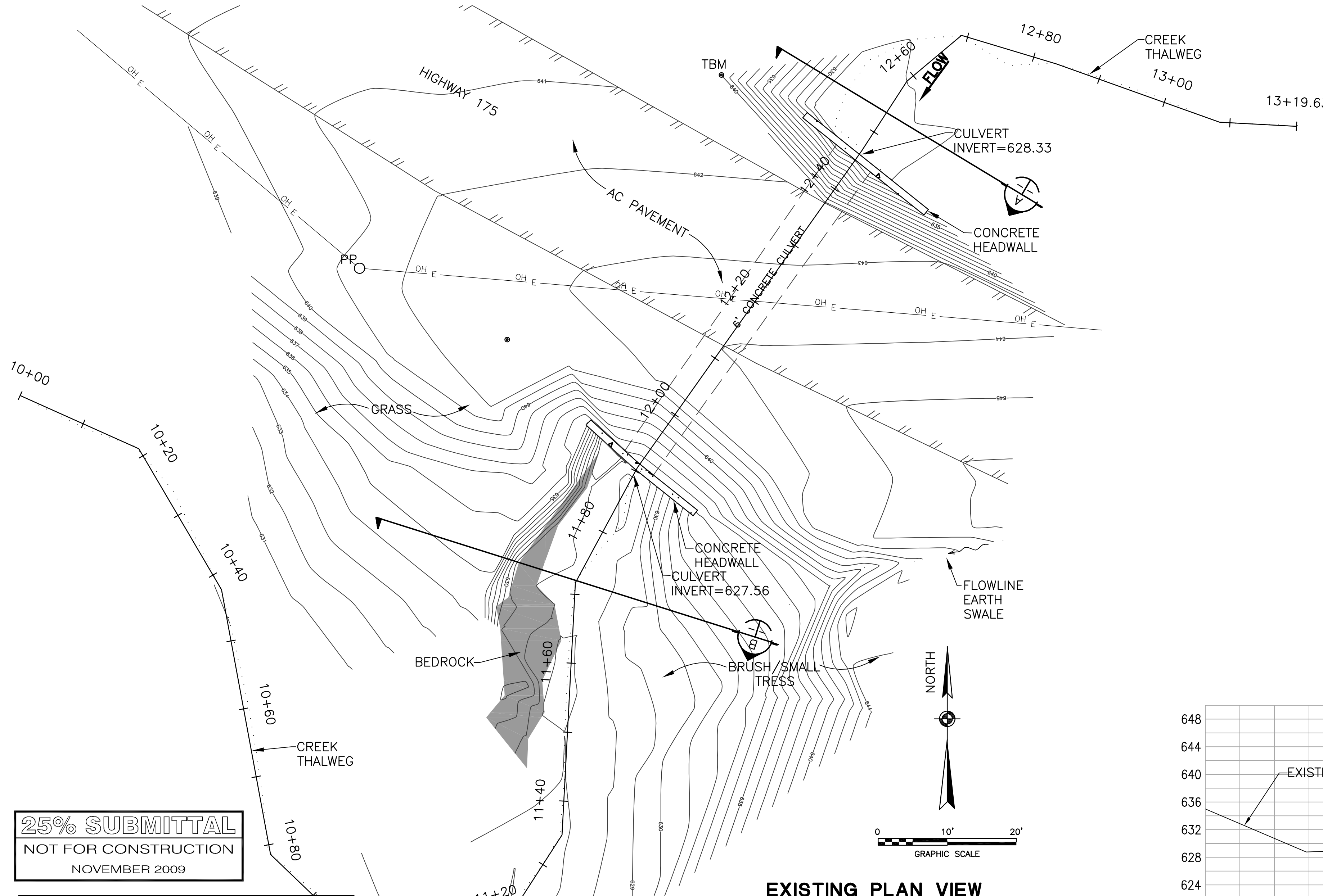
HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT HWY 175
FISH PASSAGE IMPROVEMENT PROJECT
CIVIL

GENERAL NOTES

JOB NUMBER 01993-07-001

SHEET 2 OF 8

G-2

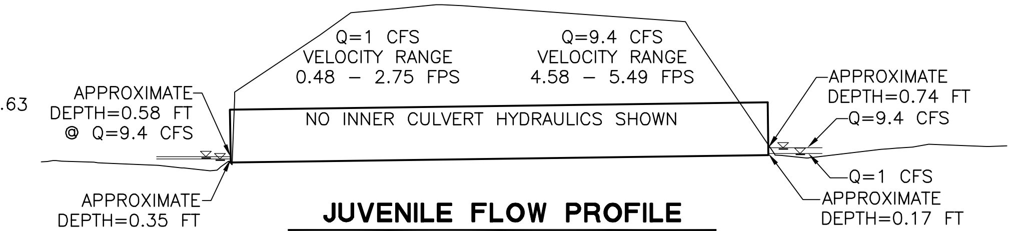


EXISTING PLAN VIEW

SCALE: SEE SCALE BAR

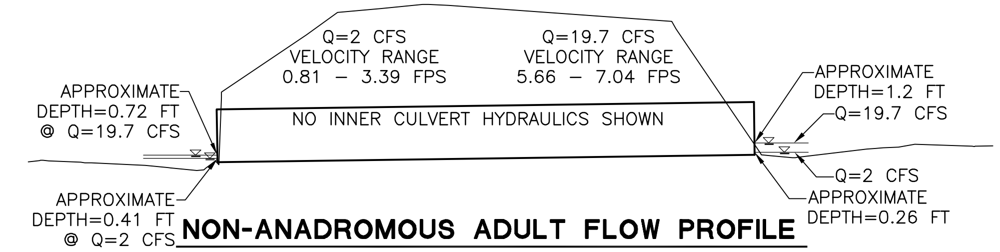
25% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER 2009

NOTE:
LOCATION OF EXISTING UTILITIES & STRUCTURES ARE FROM THE BEST INFORMATION AVAILABLE. EXACT LOCATION AND COMPLETENESS ARE NOT GUARANTEED. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICES ALERT (800) 227-2600 A MIN. OF 48 HOURS PRIOR TO ANY EXCAVATION AND POTHOLE FOR EXACT LOCATION.



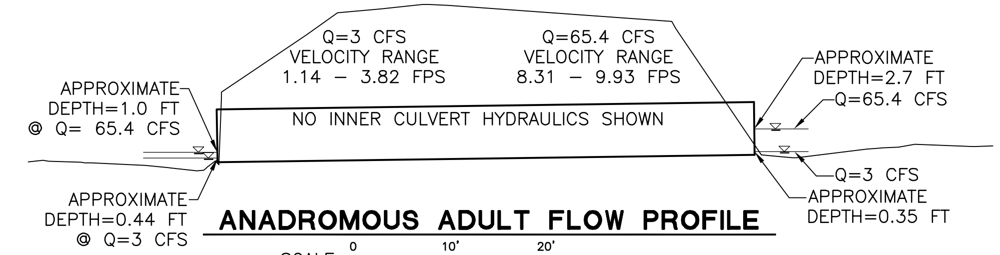
JUVENILE FLOW PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE



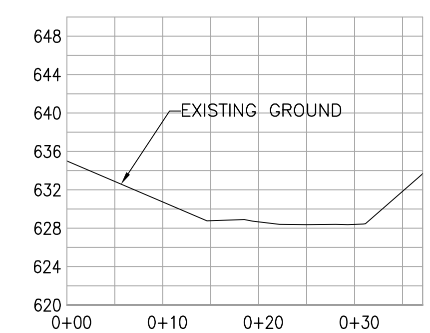
NON-ANADROMOUS ADULT FLOW PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE



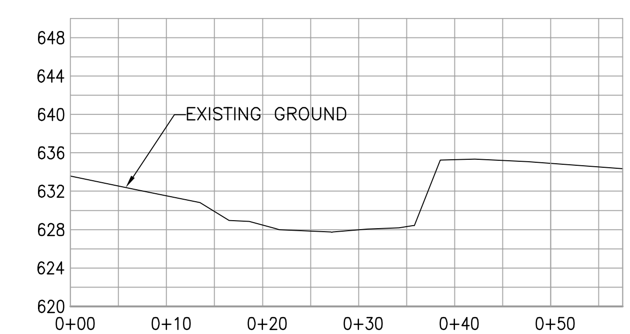
ANADROMOUS ADULT FLOW PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE



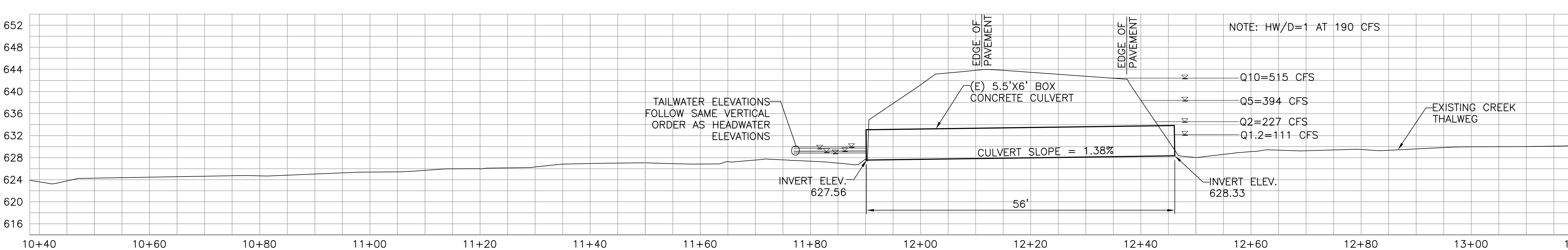
A EXISTING UPSTREAM CHANNEL XS

SCALE: 0 10' 20' GRAPHIC SCALE



B EXISTING TAILWATER CONTROL XS

SCALE: 0 10' 20' GRAPHIC SCALE



EXISTING THALWEG PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT

DES PTJ | DRN PTJ | SUPV SAA | CHK SAA

SEE SCALE BAR

SEAL

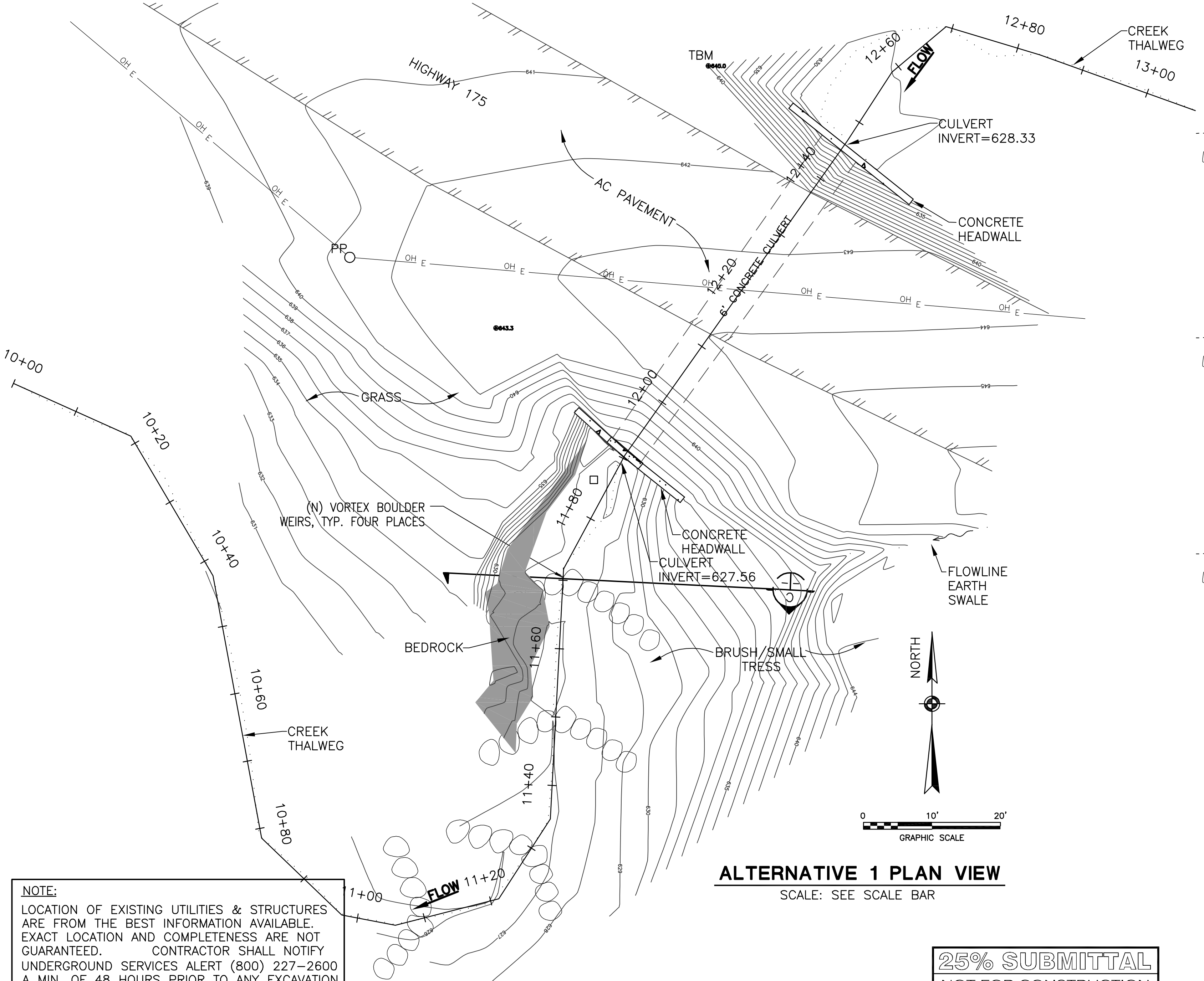
HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT HWY 175
FISH PASSAGE IMPROVEMENT PROJECT
CIVIL

EXISTING CONDITIONS

JOB NUMBER 01993-07-001

SHEET 3 OF 5

C-1

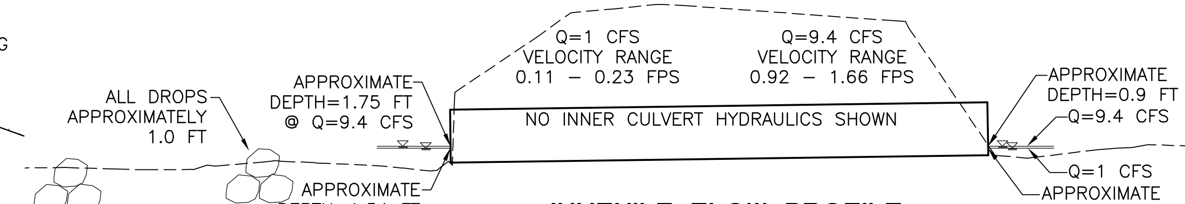


ALTERNATIVE 1 PLAN VIEW

SCALE: SEE SCALE BAR

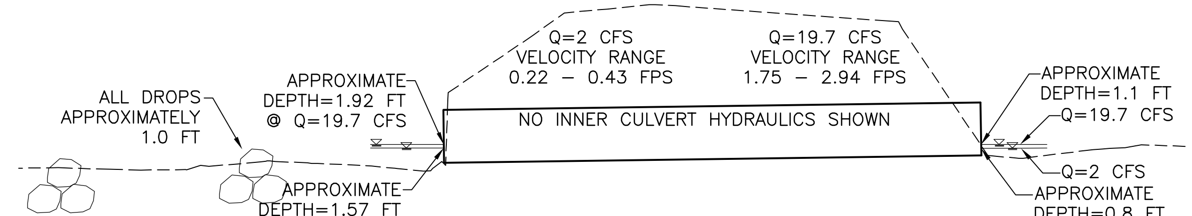
NOTE:
LOCATION OF EXISTING UTILITIES & STRUCTURES ARE FROM THE BEST INFORMATION AVAILABLE. EXACT LOCATION AND COMPLETENESS ARE NOT GUARANTEED. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICES ALERT (800) 227–2600 A MIN. OF 48 HOURS PRIOR TO ANY EXCAVATION AND POTHOLE FOR EXACT LOCATION.

25% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER 2009



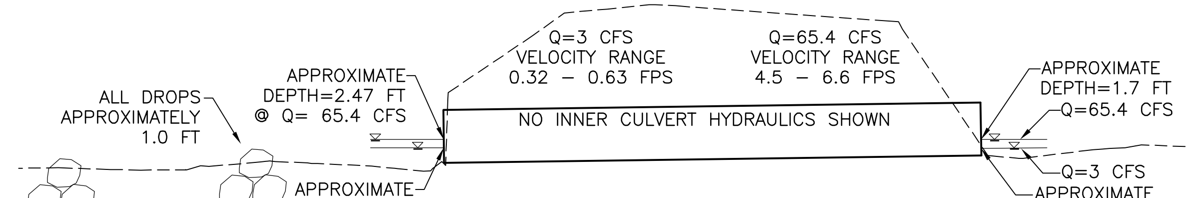
JUVENILE FLOW PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE



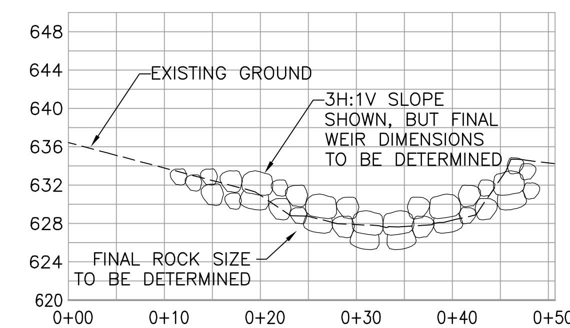
NON-ANADROMOUS ADULT FLOW PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE



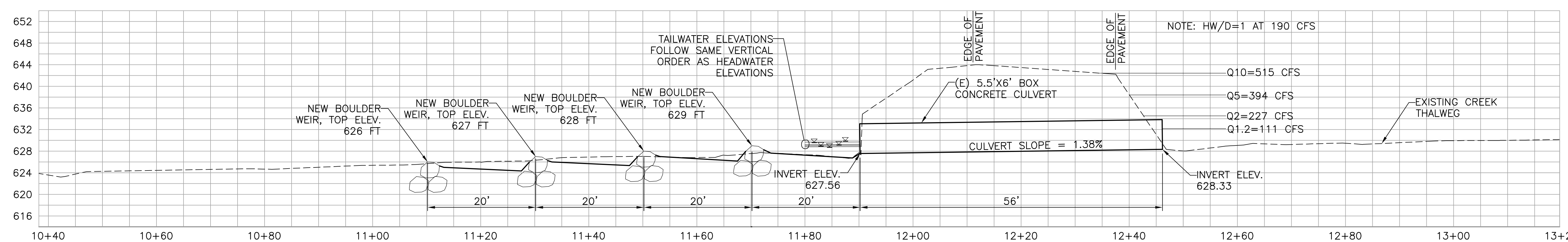
ANADROMOUS ADULT FLOW PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE



C BOULDER WEIR, TYPICAL

SCALE: 0 10' 20' GRAPHIC SCALE



ALTERNATIVE 1 PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501–0417
PH (707) 443–8326
FAX (707) 444–8330

SUBCONSULTANT

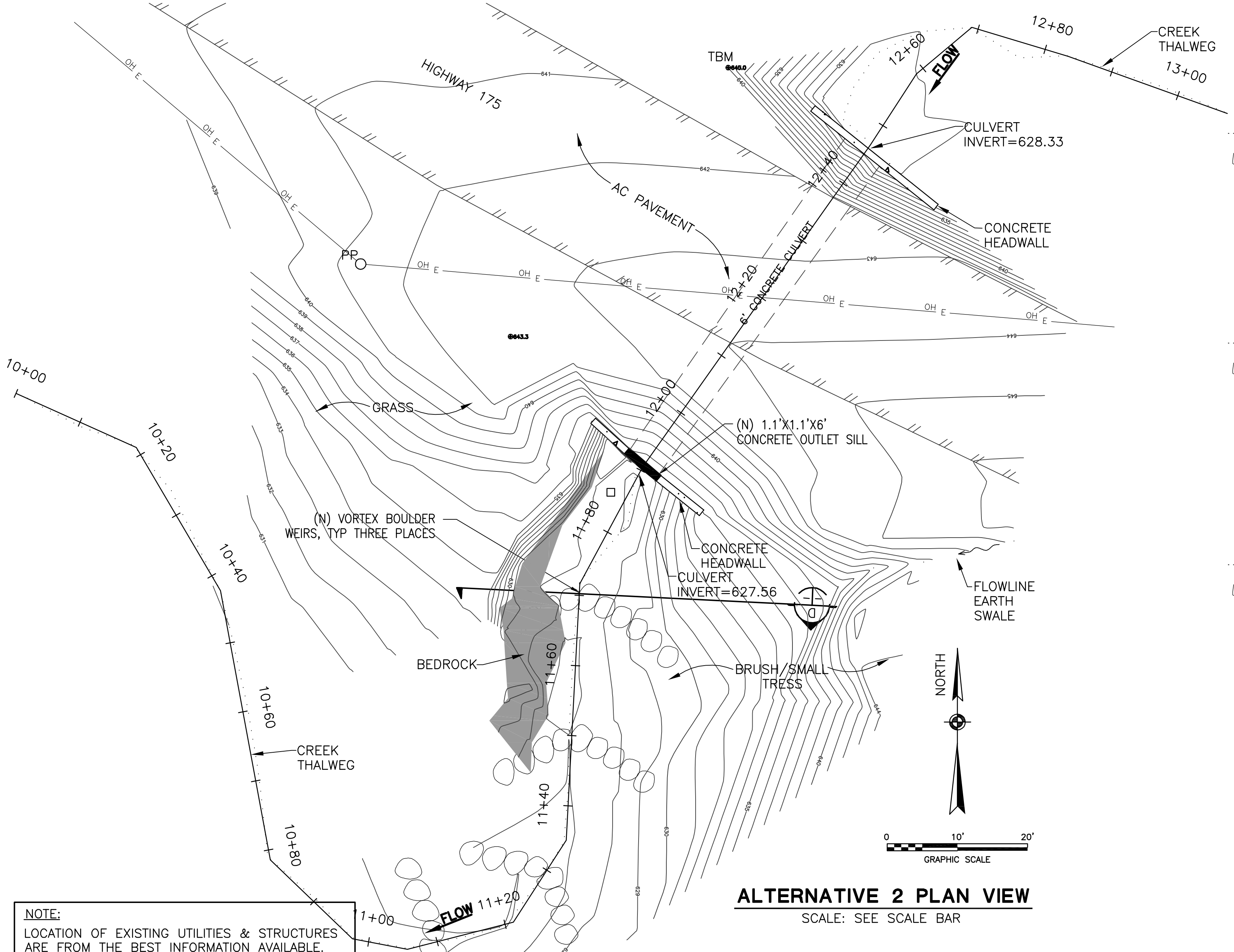
DES PTJ
DRN PTJ
SUPV SAA
CHK SAA

SEE SCALE BAR

SEAL

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT HWY 175
FISH PASSAGE IMPROVEMENT PROJECT
CIVIL
ALTERNATIVE 1
BOULDER WEIRS

JOB NUMBER 01993–07–001
SHEET 4 OF 5
A–1

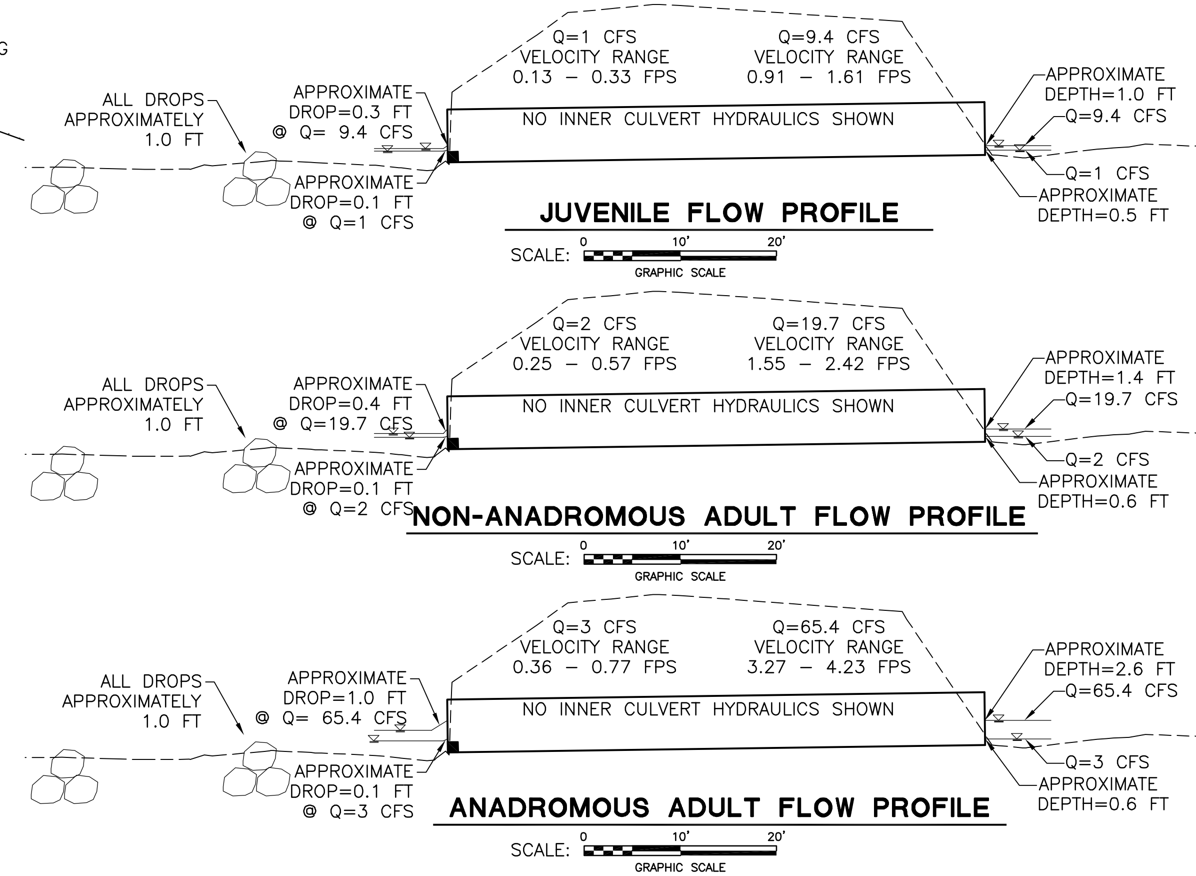


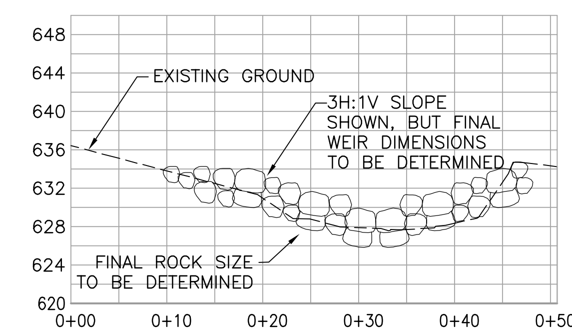
ALTERNATIVE 2 PLAN VIEW

SCALE: SEE SCALE BAR

NOTE:
LOCATION OF EXISTING UTILITIES & STRUCTURES ARE FROM THE BEST INFORMATION AVAILABLE. EXACT LOCATION AND COMPLETENESS ARE NOT GUARANTEED. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICES ALERT (800) 227-2600 A MIN. OF 48 HOURS PRIOR TO ANY EXCAVATION AND POTHOLE FOR EXACT LOCATION.

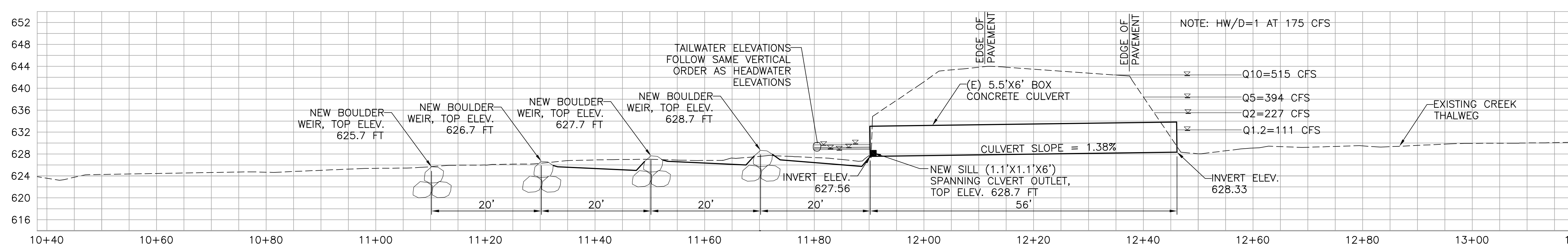
25% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER 2009





D BOULDER WEIR, TYPICAL

SCALE: 0 10' 20' GRAPHIC SCALE



ALTERNATIVE 2 PROFILE

SCALE: 0 10' 20' GRAPHIC SCALE

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330
SUBCONSULTANT

DRN PTJ | CHK SAA
DES PTJ | SUPV SAA
SEE SCALE BAR

SEAL

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT HWY 175
FISH PASSAGE IMPROVEMENT PROJECT
CIVIL
ALTERNATIVE 2
OUTLET SILL WITH BOULDER WEIRS

JOB NUMBER 01993-07-001
SHEET 5 OF 5

A-2

Appendix C
Hydrologic Calculations

Peak Flow Calculation Summary
Nissa-Kah Ck at HWY 175

Method	Q-1.2 yr (cfs)	Q-1.5 yr (cfs)	Q-2 yr (cfs)	Q-5 yr (cfs)	Q-10 yr (cfs)	Q-25 yr (cfs)	Q-50 yr (cfs)	Q-100 yr (cfs)
LP III Analysis of USGS Stream Gaging Records, average of 4 sites	**111**	**167**	**227**	**394**	**515**	**666**	**780**	**894**
Waananen & Crippen, 1977 (North Coast)			167	268	365	483	606	700

* Estimates using regional regression equations developed for the North Coast Region of California by the USGS (Waananen and Crippen, 1977):

North Coast Region

$$Q2 = 3.52\, A^{0.90}\, P^{0.89}\, H^{-0.47}$$
$$Q5 = 5.04\, A^{0.89}\, P^{0.91}\, H^{-0.35}$$
$$Q10 = 6.21\, A^{0.88}\, P^{0.93}\, H^{-0.27}$$
$$Q25 = 7.64\, A^{0.87}\, P^{0.94}\, H^{-0.17}$$
$$Q50 = 8.57\, A^{0.87}\, P^{0.96}\, H^{-0.08}$$
$$Q100 = 9.23\, A^{0.87}\, P^{0.97}$$

A = drainage area (mi2),
p = mean annual precipitation (in/yr),
H = Altitude index in thousands of feet

Mean annual precipitation was obtained from Parameter-elevation Regressions on Independent Slopes Model (PRISM). Data set provided by Oregon Climate Service (OCS) mapping program.

A (drainage area) = 2.37 mi^2
H (mean elevation of main channel (1000-ft). If less than 1000 ft, H = 1) = 1.5 from Hopland USGS quad
P (mean annual precipitation) = 40 in/yr from Prism

DS 10% elev = 765 feet
US 85% elev = 2300 feet

Log Pearson Type III Probabilistic Analysis
Nissa-kah Creek at Hwy 175

Bolded gages most similar to study area in H and P

Flow Gaging Station	Drainage Area (mi^2)	Length of Record (Years)	Precip	Alt Index	Recurrence Interval of Unit Peak Flows (Years) 1.2 (cfs/mi^2)	1.5 (cfs/mi^2)	2 (cfs/mi^2)	5 (cfs/mi^2)	10 (cfs/mi^2)	25 (cfs/mi^2)	50 (cfs/mi^2)	100 (cfs/mi^2)
ALDER C NR POTTER VALLEY CA	1.39	8	45	2.7	31.0	51.8	74.9	140.7	190.5	247.9	292.2	335.3
SODA C TRIB NR BOONVILLE CA	1.53	9	40	1.2	44.3	59.9	76.2	122.7	158.4	209.0	250.6	295.6
SF STONY C NR STONYFORD CA	2.52	9			65.4	88.2	111.2	173.1	217.5	276.9	323.1	371.0
HIGHLAND C AB HIGHLAND C DAM CA	11.9	23	37	1.9	47.1	82.3	121.4	229.3	302.2	389.9	450.5	506.4
Average Discharge per Sq. Mi. (cfs/mi^2)					**46.9**	**70.6**	**95.9**	**166.5**	**217.2**	**280.9**	**329.1**	**377.1**
Min. Discharge per Sq. Mi. (cfs/mi^2)					31.0	51.8	74.9	122.7	158.4	209.0	250.6	295.6
Max. Discharge per Sq. Mi. (cfs/mi^2)					65.4	88.2	121.4	229.3	302.2	389.9	450.5	506.4

Area	Precip	Alt Index	Nissa-kah Creek at Hwy 175 — Recurrence Interval of Peak Flows (cfs) 1.2 (cfs)	1.5 (cfs)	2 (cfs)	5 (cfs)	10 (cfs)	25 (cfs)	50 (cfs)	100 (cfs)
2.37	40	1.5	**111**	**167**	**227**	**394**	**515**	**666**	**780**	**894**

Average discharge per sq. mi from above gages

Flood Frequency based on Annual-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	Altitude	Drainage (sq mi)	Daily flow data count	Peak flow data count
11470700	ALDER C NR POTTER VALLEY CA	39.38877305	-123.04	NAD83		1.39		9

Flood Frequency based on Annual Maximum Series

Annual Maxima Series WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
	1/23/1970	250	1	9.00	250	7.08	2.40
	1/31/1963	149	2	4.50	149	4.22	2.17
	12/23/1968	140	3	3.00	140	3.96	2.15
	12/3/1970	140	4	2.25	140	3.96	2.15
	1/20/1964	122	5	1.80	122	3.45	2.09
	1/16/1973	105	6	1.50	105	2.97	2.02
	1/30/1968	42	7	1.29	42	1.19	1.62
	1/22/1972	19	8	1.13	19	0.54	1.28

Sample Size, n =	8		
Skewness =	0.34	0.34	-1.29
Mean=	120.88	3.42	1.98
Std Dev=	70.76	2.00	0.36

Outliers

Kn=	2.134	
Q-low =	**17**	**cfs**
Q-high =	**561**	**cfs**

Flow Frequency

From USGS Data

ALDER C NR POTTER VALLEY CA

Generalized Skew=	**-0.30**	A=	-0.13431
Station Skewness (log Q)=	-1.29	B=	0.60574
Station Mean (log Q)=	1.98	MSE (station skew) =	0.84021
Station Std Dev (log Q)=	0.36		
Weighted Skewness (G_W)=	**-0.56**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge per Mi^2 (cfs/mi^2)**
1.2	0.833	-0.97743	43	31.0
1.5	0.667	-0.35367	72	51.8
2.0	0.500	0.09298	104	74.9
5.0	0.200	0.85692	196	140.7
10	0.100	1.22452	265	190.5
25	0.040	1.54371	345	247.9
50	0.020	1.74272	406	292.2
100	0.010	1.90962	466	335.3

Values From K-Table for Linear interpolatior

Weighted Skewness =	-0.60	-0.50	-0.56
P	K	K	K
0.9	-1.32850	-1.32309	-1.32637
0.8	-0.79950	-0.80829	-0.80296
0.7	-0.44352	-0.45812	-0.44927
0.6	-0.15589	-0.17261	-0.16248
0.500	0.09945	0.08302	0.09298
0.429	0.27047	0.25558	0.26460
0.200	0.85718	0.85653	0.85692
0.100	1.20028	1.26180	1.22452
0.040	1.52830	1.56740	1.54371
0.020	1.72033	1.77716	1.74272
0.010	1.88029	1.95472	1.90962

Flood Frequency based on Annual-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	Drainage (sq mi)	Daily flow data count	Peak flow data count
11467850	SODA C TRIB NR BOONVILLE CA	39.02545	-123.2914	NAD83	1.53	1461	9

Flood Frequency based on Annual Maximum Series

Annual Maxima Series

WY	Date of Peak	Discharge (cfs)
	12/22/1964	394
	3/25/1971	152
	1/4/1966	138
	1/20/1964	118
	1/13/1969	113
	1/16/1973	107
	2/13/1962	89
	1/21/1967	83
	1/29/1968	50

RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1	10.00	394	11.16	2.60
2	5.00	152	4.30	2.18
3	3.33	138	3.91	2.14
4	2.50	118	3.34	2.07
5	2.00	113	3.20	2.05
6	1.67	107	3.03	2.03
7	1.43	89	2.52	1.95
8	1.25	83	2.35	1.92
9	1.11	50	1.42	1.70

Sample Size, n =	9		
Skewness =	2.48	2.48	1.00
Mean=	138.22	3.91	2.07
Std Dev=	100.55	2.85	0.24

Outliers

Kn= 2.134

Q-low = 36 cfs

Q-high = 388 cfs

Flow Frequency

From USGS Data

SODA C TRIB NR BOONVILLE CA

Generalized Skew=	**-0.30**	A=	-0.21876
Station Skewness (log Q)=	1.00	B=	0.67892
Station Mean (log Q)=	2.07	MSE (station skew) =	0.64910
Station Std Dev (log Q)=	0.24		
Weighted Skewness (G_W)=	**0.11**		

Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Predicicted Discharge (cfs)	Discharge per mi^2 (cfs/mi^2)
1.2	0.833	-0.98731	68	44.3
1.5	0.667	-0.44888	92	59.9
2.0	0.500	-0.01897	117	76.2
5.0	0.200	0.83555	188	122.7
10	0.100	1.29309	242	158.4
25	0.040	1.78927	320	209.0
50	0.020	2.11436	383	250.6
100	0.010	2.40986	452	295.6

Values From K-Table for Linear interpolatior

Weighted Skewness =	0.10	0.20	0.11
P	K	K	K
0.9	-1.27037	-1.25824	-1.26866
0.8	-0.84611	-0.84986	-0.84664
0.7	-0.53624	-0.54757	-0.53784
0.6	-0.26882	-0.28403	-0.27096
0.500	-0.01662	-0.03325	-0.01897
0.429	0.16111	0.14472	0.15880
0.200	0.83639	0.83044	0.83555
0.100	1.29178	1.30105	1.29309
0.040	1.78462	1.81756	1.78927
0.020	2.10697	2.15935	2.11436
0.010	2.39961	2.47226	2.40986

Flood Frequency based on Annuall-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	Drainage (sq mi)	Daily flow data count	Peak flow data count
11384400	SF STONY C NR STONYFORD CA	39.296	-122.753047	NAD83	2.52		11

Flood Frequency based on Annual Maximum Series

Annual Maxima Series

WY	Date of Peak	Discharge (cfs)
	1/16/1974	586
	1/23/1970	553
	1/13/1980	478
	1971-03	257
	1/16/1978	245
	2/12/1975	215
	1/16/1973	208
	1/22/1972	174
	3/27/1979	133

RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1	10.00	586	16.59	2.77
2	5.00	553	15.66	2.74
3	3.33	478	13.54	2.68
4	2.50	257	7.28	2.41
5	2.00	245	6.94	2.39
6	1.67	215	6.09	2.33
7	1.43	208	5.89	2.32
8	1.25	174	4.93	2.24
9	1.11	133	3.77	2.12

Sample Size, n =	9		
Skewness =	0.78	0.78	0.36
Mean=	316.56	8.96	2.44
Std Dev=	172.97	4.90	0.23

Outliers

Kn= 2.134

Q-low = 90 cfs

Q-high = 866 cfs

Flow Frequency

From USGS Data

SF STONY C NR STONYFORD CA

Generalized Skew=	**-0.30**	A=	-0.30099
Station Skewness (log Q)=	0.36	B=	0.84572
Station Mean (log Q)=	2.44	MSE (station skew) =	0.54665
Station Std Dev (log Q)=	0.23		
Weighted Skewness (G_W)=	**-0.06**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge per Mi^2 (cfs/mi^2)**
1.2	0.833	-0.98821	165	65.4
1.5	0.667	-0.42541	222	88.2
2.0	0.500	0.01067	280	111.2
5.0	0.200	0.84450	436	173.1
10	0.100	1.27437	548	217.5
25	0.040	1.72829	698	276.9
50	0.020	2.01907	814	323.1
100	0.010	2.27899	935	371.0

Values From K-Table for Linear interpolatior

Weighted Skewness =	-0.10	0.00	-0.06
P	K	K	K
0.9	-1.29178	-1.28155	-1.28812
0.8	-0.83639	-0.84162	-0.83826
0.7	-0.51207	-0.52440	-0.51648
0.6	-0.23763	-0.25335	-0.24326
0.500	0.01662	0.00000	0.01067
0.429	0.19339	0.17733	0.18764
0.200	0.84611	0.84162	0.84450
0.100	1.27037	1.28155	1.27437
0.040	1.71580	1.75069	1.72829
0.020	1.99973	2.05375	2.01907
0.010	2.25258	2.32635	2.27899

Flood Frequency based on Annual-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	P	alt index H	Drainage (sq mi)	Daily flow data count	Peak flow data count
11448900	HIGHLAND C AB HIGHLAND C DAM CA	38.91962268	-122.92083	NAD83	37	1.9	11.9	5844	24

Flood Frequency based on Annual Maximum Series

Annual Maxima Series WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
	1/16/1974	3140	1	24.00	3140	88.92	3.50
	12/22/1964	3080	2	12.00	3080	87.22	3.49
	1/23/1970	2980	3	8.00	2980	84.38	3.47
	1/14/1978	2710	4	6.00	2710	76.74	3.43
	1/16/1973	2390	5	4.80	2390	67.68	3.38
	10/12/1962	2320	6	4.00	2320	65.70	3.37
	2/24/1958	2280	7	3.43	2280	64.56	3.36
	2/21/1956	1860	8	3.00	1860	52.67	3.27
	3/21/1975	1810	9	2.67	1810	51.25	3.26
	12/1/1960	1800	10	2.40	1800	50.97	3.26
	1/20/1964	1520	11	2.18	1520	43.04	3.18
	2/16/1959	1440	12	2.00	1440	40.78	3.16
	12/15/1968	1430	13	1.85	1430	40.49	3.16
	2/24/1957	1370	14	1.71	1370	38.79	3.14
	1/29/1968	1320	15	1.60	1320	37.38	3.12
	2/8/1960	1290	16	1.50	1290	36.53	3.11
	1/4/1966	1290	17	1.41	1290	36.53	3.11
	12/3/1970	1230	18	1.33	1230	34.83	3.09
	12/2/1966	1210	19	1.26	1210	34.26	3.08
	12/22/1971	604	20	1.20	604	17.10	2.78
	11/15/1954	408	21	1.14	408	11.55	2.61
	4/7/1976	229	22	1.09	229	6.48	2.36
	1/2/1977	85	23	1.04	85	2.41	1.93

Sample Size, n =	23		
Skewness =	0.07	0.07	-1.86
Mean=	1643.30	46.53	3.11
Std Dev=	870.56	24.65	0.38
Outliers			
Kn=	2.134		
Q-low =	**204 cfs**		
Q-high =	**8,264 cfs**		

Flow Frequency

From USGS Data

HIGHLAND C AB HIGHLAND C DAM CA

Generalized Skew=	**-0.30**	A=	0.03912
Station Skewness (log Q)=	-1.86	B=	0.45543
Station Mean (log Q)=	3.11	MSE (station skew) =	0.74882
Station Std Dev (log Q)=	0.38		
Weighted Skewness (G_W)=	**-0.75**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge per mi^2 (cfs/mi^2)**
1.2	0.833	-0.96828	560	47.1
1.5	0.667	-0.32413	980	82.3
2.0	0.500	0.12379	1,445	121.4
5.0	0.200	0.85656	2,729	229.3
10	0.100	1.17471	3,596	302.2
25	0.040	1.46856	4,640	389.9
50	0.020	1.63498	5,360	450.5
100	0.010	1.76990	6,026	506.4

Values From K-Table for Linear interpolatior

Weighted Skewness =	-0.80	-0.70	-0.75
P	K	K	K
0.9	-1.33640	-1.33294	-1.33465
0.8	-0.77986	-0.79022	-0.78510
0.7	-0.41309	-0.42851	-0.42089
0.6	-0.12199	-0.13901	-0.13060
0.500	0.13199	0.11578	0.12379
0.429	0.29961	0.28516	0.29230
0.200	0.85607	0.85703	0.85656
0.100	1.16574	1.18347	1.17471
0.040	1.44813	1.48852	1.46856
0.020	1.60604	1.66325	1.63498
0.010	1.73271	1.80621	1.76990

USGS Gaged Streams near the Hwy 175 and Nissa-Kah Creek crossing. Exceedance flows are given in per unit drainage area.

Station Number	Station Name	Drainage Area (sq. miles)	Record Length (years)	Coverage (WY)	H (Altitude Index per 1,000 ft)	P (Precipitation (in/yr))	Latitude	Longitude
11467850	SODA C TRIB NR BOONVILLE CA	1.53	4	1964-1968	1.2	40	39.02545	-123.2913963
11448500	ADOBE C NR KELSEYVILLE CA	6.36	24	1954-1978	2.1	41	38.92684	-122.8808283
11448900	HIGHLAND C AB HIGHLAND C DAM CA	11.9	16	1962-1978	1.9	37	38.91962	-122.9208298
11464050	DRY C TRIB NR HOPLAND CA	1.19	2	1967-1969	1.4	48	38.88601	-123.1552822
11473980	GOFORTH C A DOS RIOS CA	3.83	3	1965-1968	2	45	39.7124	-123.342514

Summary - Average of exceedance flows
Nissa-Kah Creek flows

Criteria for determining fish passage flows at stream crossings

Species and Age Class	Exceedance Flows: Lower Fish Passage Flow *	Exceedance Flows: Upper Fish Passage Flow
Adult Anadromous Salmonids	50% EP or 3 cfs	1%
Non-Anadromous Adult Salmonids	90% EP or 2 cfs	5%
Juvenile Salmonids	95% EPor 1 cfs	10%

* Use the greater of the two for determining the lower fish passage flow

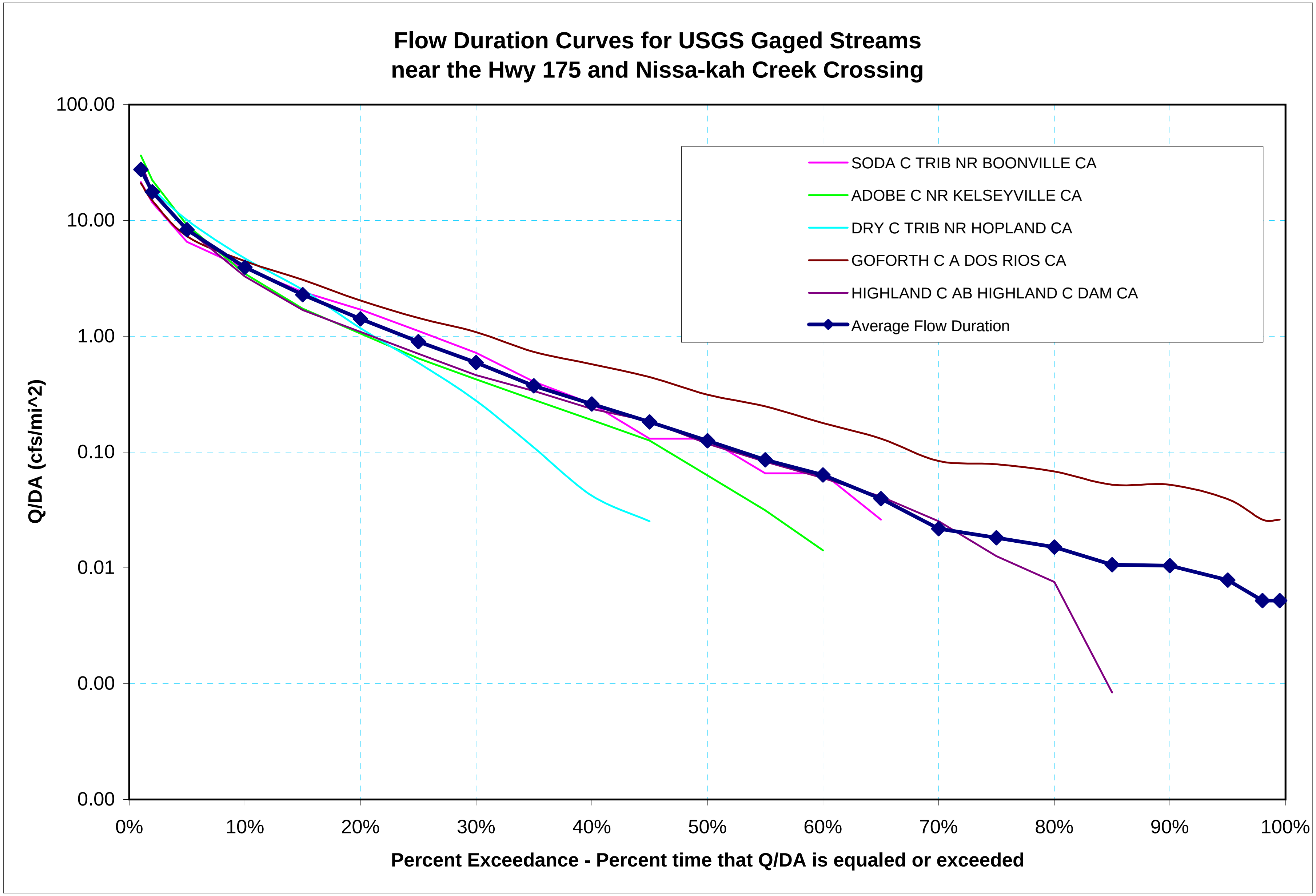
Hwy 175 crossing **2.37** **sq mi**

Species and Age Class	Exceedance Flows: Lower Fish Passage Flow (cfs)	Exceedance Flows: Upper Fish Passage Flow (cfs)
Adult Anadromous Salmonids	3	65.3
Non-Anadromous Adult Salmonids	2	19.6
Juvenile Salmonids	1	9.4

**Fish Passage flows at Hwy 175 Crossing at Nissa-kah Creek based on average exceedance flows from 5 local stream gages scaled by drainage area.*

Flow Duration Table for Gaged Streams within and near the Hwy 175 crossing at Nissa-kah creek project site . The average of the exceedance flows is used to estimate the fish passage flows.

Percent Time Flow is Equalled or Exceeded	SODA C TRIB NR BOONVILLE CA	ADOBE C NR KELSEYVILLE CA	HIGHLAND C AB HIGHLAND C DAM CA	DRY C TRIB NR HOPLAND CA	GOFORTH C A DOS RIOS CA	Minimum Flow	Maximum Flow	Average Flow	Minimum Flow at Nissa-Ka Ck	Maximum Flow at Nissa-Ka Ck	Average Flow at Nissa-Ka Ck
	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	cfs	cfs	cfs
1%	21.438	36.376	31.548	27.479	20.940	20.940	36.376	27.556	49.628	86.211	65.308
2%	14.248	22.280	17.647	19.160	14.883	14.248	22.280	17.643	33.769	52.803	41.815
5%	6.536	9.119	8.403	10.084	7.311	6.536	10.084	8.291	15.490	23.899	19.649
10%	3.856	3.459	3.277	4.706	4.439	3.277	4.706	3.947	7.767	11.153	9.355
15%	2.418	1.730	1.681	2.521	3.068	1.681	3.068	2.283	3.983	7.271	5.412
20%	1.699	1.053	1.092	1.176	2.037	1.053	2.037	1.412	2.497	4.827	3.346
25%	1.111	0.645	0.706	0.588	1.436	0.588	1.436	0.897	1.394	3.403	2.126
30%	0.719	0.425	0.462	0.277	1.084	0.277	1.084	0.593	0.657	2.568	1.406
35%	0.405	0.283	0.336	0.109	0.731	0.109	0.731	0.373	0.259	1.733	0.884
40%	0.261	0.189	0.235	0.042	0.574	0.042	0.574	0.260	0.100	1.361	0.617
45%	0.131	0.126	0.185	0.025	0.444	0.025	0.444	0.182	0.060	1.052	0.432
50%	0.131	0.063	0.118	0.000	0.313	0.000	0.313	0.125	0.000	0.743	0.296
55%	0.065	0.031	0.083	0.000	0.248	0.000	0.248	0.085	0.000	0.588	0.203
60%	0.065	0.014	0.060	0.000	0.178	0.000	0.178	0.063	0.000	0.421	0.150
65%	0.026	0.000	0.041	0.000	0.131	0.000	0.131	0.040	0.000	0.309	0.094
70%	0.000	0.000	0.025	0.000	0.084	0.000	0.084	0.022	0.000	0.198	0.052
75%	0.000	0.000	0.013	0.000	0.078	0.000	0.078	0.018	0.000	0.186	0.043
80%	0.000	0.000	0.008	0.000	0.068	0.000	0.068	0.015	0.000	0.161	0.036
85%	0.000	0.000	0.001	0.000	0.052	0.000	0.052	0.011	0.000	0.124	0.025
90%	0.000	0.000	0.000	0.000	0.052	0.000	0.052	0.010	0.000	0.124	0.025
95%	0.000	0.000	0.000	0.000	0.039	0.000	0.039	0.008	0.000	0.093	0.019
98%	0.000	0.000	0.000	0.000	0.026	0.000	0.026	0.005	0.000	0.062	0.012
99.5%	0.000	0.000	0.000	0.000	0.026	0.000	0.026	0.005	0.000	0.062	0.012



Michael Love and Associates
PO Box 4477 Arcata CA 95518

Appendix D
Opinion of Probable Construction and Project Costs

Nissa-Kah Creek Fish Passage Improvement Project at Highway 175 Crossing

Engineers Opinion of Probable Construction and Project Cost - Based on November 2009 25% Design Submittal
Prepared for: Hopland Band of Pomo Indians

Alternative 1: Boulder Weirs

Item No	*Item Description*	*Quantity*	*Unit*	*Unit Cost*	*Total*
1	Mobilization and Demobilization	1	LS	$15,000	$15,000
2	Traffic Control	1	LS	$20,000	$20,000
3	Erosion, Sediment Control, and Creek Bypass	1	LS	$25,000	$25,000
4	Clearing, Grubbing, Demolition, and Disposal	1	LS	$15,000	$15,000
5	Excavation and Grading	1	LS	$15,000	$15,000
7	Native Backfill & Compaction	1	LS	$5,000	$5,000
8	Boulder Weirs	4	EACH	$10,000	$40,000
9	Revegetation of Disturbed Area	1	LS	$5,000	$5,000
10	Construction Staking	1	LS	$15,000	$15,000
				Subtotal:	$155,000
				Estimating Contingency @ 30% (Rounded):	$47,000
				OPINION OF PROBABLE CONSTRUCTION COST (Rounded):	**$202,000**
				Final PS&E	$30,000
				Bidding Assistance	$5,000
				Construction Management	$50,000
				OPINION OF PROBABLE PROJECT COST (Rounded):	**$287,000**

Nissa-Kah Creek Fish Passage Improvement Project at Highway 175 Crossing

Engineers Opinion of Probable Construction and Project Cost - Based on November 2009 25% Design Submittal
Prepared for: Hopland Band of Pomo Indians

Alternative 2: Boulder Weirs with Outlet Sill

Item No	***Item Description***	***Quantity***	***Unit***	***Unit Cost***	***Total***
1	Mobilization and Demobilization	1	LS	$15,000	$15,000
2	Traffic Control	1	LS	$20,000	$20,000
3	Erosion, Sediment Control, and Creek Bypass	1	LS	$25,000	$25,000
4	Clearing, Grubbing, Demolition, and Disposal	1	LS	$15,000	$15,000
5	Excavation and Grading	1	LS	$15,000	$15,000
7	Native Backfill & Compaction	1	LS	$5,000	$5,000
8	Boulder Weirs	4	EACH	$10,000	$40,000
9	Outlet Sill	1	LS	$5,000	$5,000
10	Revegetation of Disturbed Area	1	LS	$5,000	$5,000
11	Construction Staking	1	LS	$15,000	$15,000
				Subtotal:	$160,000
				Estimating Contingency @ 30% (Rounded):	$48,000
				OPINION OF PROBABLE CONSTRUCTION COST (Rounded):	**$208,000**
				Final PS&E	$30,000
				Bidding Assistance	$5,000
				Construction Management	$50,000
				OPINION OF PROBABLE PROJECT COST (Rounded):	**$293,000**

0199307001.11007

Design Report for a Fish Passage Improvement Project on Nissa-kah Creek at Nokomis Road

Prepared for:
Hopland Band of the Pomo Indians

Prepared by:

WINZLER & KELLY

Michael Love & Associates
Hydrologic Solutions
PO Box 4477 • Arcata, CA 95518 • (707) 476-8938

DESIGN REPORT FOR A FISH PASSAGE IMPROVEMENT PROJECT ON NISSA-KAH CREEK AT NOKOMIS ROAD

Prepared for:
Hopland Band of Pomo Indians
3000 Shanel Road, P.O. Box 610
Hopland, CA 95449

Prepared by:

Steven Allen, P.E.

Winzler & Kelly
633 Third Street, Eureka, CA 95501
(707) 443-8326

Michael Love, P.E.

Michael Love & Associates
427 F St, Suite 223, Eureka CA 95501
(707) 476-8938 / mlove@h2odesigns.com

NOVEMBER 2009

TABLE OF CONTENTS

Page

TABLES

FIGURES

APPENDICES

1.0 PROJECT DESCRIPTION

Michael Love & Associates (MLA) and Winzler & Kelly have been contracted by the Hopland Band of the Pomo Indians (Tribe) to design fish passage improvements for Nissa-kah Creek at the Nokomis Road crossing. The project is funded through a grant from the US Fish and Wildlife Service Tribal Wildlife Grants Program.

The road and stream crossing is maintained by the County of Mendocino Department of Transportation. The Tribe requested that a design be developed for improving upstream fish passage conditions while maintaining the existing concrete box culvert, which was recently extended at the upstream end to widen the road. The culvert is in good structural condition and has a relatively large fill above it. The design should accommodate both upstream and downstream passage for adult and juvenile steelhead trout. The fish passage design described in this report is being provided for review by the Tribe, County staff, and permitting agencies.

1.1 Background

The existing Nissa-kah Creek stream crossing on Nokomis Road consists of a concrete box culvert 6 feet wide by 7 feet tall. The culvert is nearly 80 feet in length, and has a 10 foot long outlet apron. The overall combined slope of the culvert and apron is 0.7%. The outlet apron is perched nearly 5 feet above the downstream channel. The face of the apron is armored with sloping riprap that creates a cascade. No distinct pool is present at the toe of the riprap. Downstream of the crossing the channel is straight for approximately 150 feet and has a relatively uniform cross sectional shape and channel slope of 2.0%. This reach appears to have been realigned, likely when the original culvert crossing was constructed.

This concrete box culvert was identified in the *Hopland Band of Pomo Indian Reservation Stream Crossing Inventory and Fish Passage Evaluation* (Taylor, 2006) as being a high priority crossing for improving fish passage conditions. The report, which refers to the site as Pomo-01, cites the perched outlet apron, riprap cascade, and lack of a leaping pool creates a barrier to upstream movement for all fish, including adult and juvenile steelhead/rainbow trout. The flat concrete bottom of the culvert also creates a depth barrier at low flows and velocity barrier at high flows.

The upstream channel does not show signs of frequent backwatering from the culvert, such as sediment deposition that is commonly found at inlets of undersized culverts. However, based on the culvert capacity analysis described below, we estimate the existing culvert has a capacity of 330 cfs when the inlet is flowing full (HW/D = 1). This peak flow corresponds to a return interval of approximately 5 years based on the hydrologic analysis described below. The flow resulting in headwater depth at the inlet overtopping Nokomis Road is approximately 665 cfs, which has a return interval greater than the 50 years.

The 2006 evaluation report recommends a complete replacement for this crossing due to its undersized nature. However, the crossing, reconstructed in 2001, is in good condition and replacement would be costly. Additionally, a habitat assessment of Nissa-Kah Creek (Taylor,

2008) characterized the salmonid habitat in the stream as “marginal” due in large part to downstream limiting factors beyond the boundaries of the Rancheria. This makes it difficult to justify a costly full replacement when modifications to the existing culvert outlet could greatly improve fish passage conditions.

The Tha-Layla tributary channel enters Nissa-kah creek on the right bank 46 feet downstream of the culvert outlet apron. The tributary has a 3 foot diameter corrugated metal culvert that crosses under Nokomis Road. This 180-foot long culvert has a slope of 2.2% and a 2-foot drop at the outlet, and is currently ranked as a low priority for fish passage improvements due to lack of upstream habitat. Providing passage through this culvert was not included in the current scope of work.

Approximately 250 ft downstream of the crossing begins a sharp bend in the stream with steep, nearly vertical, banks along the left side of the channel. Downstream of this point, access to the channel is difficult and numerous large trees would need to be removed. Downstream of the project area (and upstream of the Highway 175 culvert) there are several bedrock constrictions that are expected to serve as natural control points to limit future channel down-cutting.

1.2 Coordination with Stakeholders

A project initiation meeting was held on January 31, 2008 at Tribal offices. The meeting was intended to facilitate project coordination and define project objectives and constraints. In attendance were Tribal representatives, project engineers from Winzler & Kelly and Michael Love & Associates, Ross Taylor serving as the project’s fisheries biologist, and staff from Mendocino Department of Transportation, CalTrans, National Marine Fisheries Service (NOAA Fisheries), and California Department of Fish and Game (CDFG). The group discussed development of a design that involved retrofitting the existing culvert and adding grade control to reduce or eliminate the drop across the outlet apron.

1.3 Design Objectives and Constraints

The objective of the project is to improve passage through the Nokomis Road culvert for all age classes of steelhead/rainbow trout while leaving the existing culvert in place. Additionally, the project should not reduce the flood flow capacity of the culvert and loss of riparian and large oak trees should be minimized or avoided. Limiting the project extent to upstream of the above mentioned sharp bend to avoid the steep vertical banks was considered during the design development.

1.4 Selection of Preferred Design Approach

Several different options were considered for improving fish passage at the existing culvert. Although intertwined, the options were divided into two categories: those that addressed fish passage conditions in the culvert and those that addressed the drop across the outlet apron.

1.4.1 Culvert Options

One method of improving fish passage conditions in a culvert is to retrofit the crossing by installing a series of baffles along the flowline to increase depth and reduce water velocity in the culvert. However, the additional hydraulic roughness created by the baffles can reduce the capacity of the culvert. Additionally, baffles in undersized culverts frequently catch debris, further reducing culvert capacity and creating a maintenance burden. Because the current capacity of the culvert is insufficient and should not be reduced, placing baffles inside the culvert was considered an infeasible option for this site.

One approach to increasing water depths and reducing water velocities at fish migration flows while not reducing the culvert capacity is to raise the downstream water surface sufficiently to backwater the culvert. Because the culvert bottom is relatively flat, it is possible to backwater the entire culvert at low flows by constructing a sill across the end of the outlet apron. An outlet sill can be designed to increase water depth in the culvert at fish passage flows while not affecting the depth in the culvert at higher flows.

1.4.2 Downstream Channel Grade Control Options

As previously mentioned, Nissa-kah Creek downstream of Nokomis Road appears to have been realigned. Assuming the outlet apron was originally constructed at or near grade with the streambed, it appears that the channel has incised (downcut) approximately 4.6 feet at the outlet of the culvert since construction of the original crossing, resulting in a perched outlet. It is assumed that the large rock located downstream of the concrete apron was placed after the channel incision occurred. The approach for addressing the perched outlet is to raise the water surface downstream of the culvert, allowing fish to swim or leap onto the culvert apron, which would be backwatered by the outlet sill. Raising the water surface downstream of the culvert requires use of grade control, which should be designed to remain stable up to the 100-year return flow (per NOAA Fisheries and CDFG guidelines) and provide suitable conditions for fish passage during migration flows. Because the sill would be placed at the end of the wide apron, outside of the culvert, the risk of collecting debris is much lower than baffles.

We investigated several methods for controlling channel grade while providing upstream fish passage, including profile restoration, concrete weirs, rock weirs, and various types of roughened rock channels.

1.4.2.1 Channel Profile Restoration Option

While restoring the channel profile to its historic elevation from the culvert to the downstream limit of the incision could improve geomorphic channel function and habitat, it would require a costly large-scale project and substantial disturbance to the channel and riparian vegetation. The project would extend for more than 300 feet and much of the downstream channel banks would be disturbed to provide access for heavy machinery. Therefore, a design approach that limits the overall length of channel reconstruction to the 200-foot long straight channel reach downstream of the culvert was considered preferable.

1.4.2.2 Concrete Weirs Option

Concrete weirs can be designed to provide suitable passage conditions for both adult and juvenile steelhead by taking advantage of their leaping abilities. This type of fish passage structure would consist of a series of pools formed by concrete weirs. The weirs form a series of drops that fish leap or swim over, while the pools dissipate energy of the plunging water and provide good leaping conditions and resting areas for the fish. Because of the extensive excavation and formwork required for concrete, they can be costly to construct. Although stable, they often fail to provide fish passage at higher fish migration flows due to excessive turbulence and lack of hydraulic diversity across the weir crest. They also can have problems with debris and sedimentation and often fail to address passage of non-salmonids.

1.4.2.3 Rock Weirs Option

Rock weirs are discrete channel spanning structures with native streambed material between them. They can be an effective means of providing fish passage, especially for situations with low head differences in low gradient streams. The native bed and banks between weirs is susceptible to scour, which is controlled by providing sufficient spacing between weirs to create pools that can dissipate the flow's energy. The spacing requirement usually limits the hydraulic gradient of rock weirs to a 4% slope (Saldi-Caromile et al., 2004). Limiting the new channel at the Nissa-kah crossing to a 4% slope would extend the project downstream well beyond the desired limits of disturbance.

1.4.2.4 Roughened Rock Channel Option (Preferred Alternative)

Another grade control option is the roughened rock channel, also known as a "nature-like fishway". It relies on constructing an over-steepened reach of channel based on the form and function of naturally steep channels. The bed of the roughened channel is comprised of *engineered streambed material* combined with large *rock structures*. This mix of material creates a streambed structure similar to what is found in naturally occurring steep stream reaches. Although they often cost more to construct than boulder weirs due to the amount of material required, they are far more stable and have been found to provide passage for all size classes of fish over a wider range of flows. They can be designed as over-steepened riffles or small chutes across short reaches of stream. In longer reaches, or where more than a couple feet of drop must be overcome, the roughened channel can have a step pool or cascade and pool type morphology (CDFG, 2009). As in natural steep streams, the pools help dissipate the flow's energy.

This project must overcome a relatively large drop. A step-pool roughened channel was considered because this type of channel is efficient at dissipating energy in the pools. The design of a step pool roughened channel is based on the morphology of steep streams found in nature. Montgomery and Buffington (1997) describe step pool channels as typically having cobble-boulder bed material, vertically oscillatory bedform patterns, typical pool spacing between 1 to 4 channel widths, and slopes typically ranging from 3% to 6.5%. They define cascade type channels as typically having boulder bed material, random bed pattern with typical pool spacing of less than 1 channel width and slopes greater than about 6.5%. Although not present within the stream reaches adjacent to the Nokomis Road crossing, a mixed step pool and cascade channel morphology was identified further upstream during habitat typing (Taylor, 2008). This portion of the channel has slopes ranging from 7 to 13% and drops ranging from 3 to 5 feet. Taylor also noted that the highest abundance of juvenile salmonids and resident trout were found in these sections of cascades.

To meet the project objectives and constraints, the new channel will require a slope of about 6%, which is within the slope range recommended by CDFG (2009) for step pool roughened channels. This will limit construction to within 200 feet downstream of the crossing and avoid extending beyond that point and into the downstream channel bend.

For these reasons, a step pool roughened channel at a 6% slope was chosen as the apparent best alternative for the Nokomis road crossing.

2.0 STEP POOL ROUGHENED CHANNEL DESIGN

2.1 Topographic Survey

On February 26 and 27, 2008, Gutierrez Land Surveying, a licensed land surveyor, and MLA staff conducted a topographic survey of the culvert and adjacent channel. The survey extended 300 feet downstream and 50 feet upstream of the crossing. From the survey, a plan map with 1-foot contours was generated for use in developing the fish passage design for the site. Minimizing channel disturbance and location for equipment access determined the limits of the topographic survey to 300 ft downstream of the culvert where a large bend in the channel is located.

2.2 Project Hydrology

Development of the design required an estimate of the fish passage design flows and peak flows associated with various recurrence intervals. Peak flow estimates were used for structural design of the channel and for culvert capacity analysis. The hydrologic analysis is detailed in the **Appendix A**.

Table 1 provides the watershed area and mean basin elevation estimated from a 1:24,000 USGS topographic map as well the mean annual precipitation obtained from regional isoheytal maps produced by USDA-NRCS (1999):

Table 1 - Watershed Information

Drainage Area:	1.94	Square miles
Mean Basin Elevation:	1,530	Feet
Mean Annual Precipitation:	40	Inches/year

2.2.1 Fish Passage Design Flows

Fish passage design flows were used to evaluate fish passage conditions within the new step pool roughened channel and inside the culvert. The design objective was to satisfy fish passage criteria between the low and high fish passage design flows.

It is neither necessary nor practical to provide fish passage at all flows, but it should be provided at the flows that fish typically move upstream. For adult steelhead, this upstream movement is typically associated with their spawning migration. Daily and seasonal movement of juvenile salmonids can be associated with predation avoidance, seeking refugia from poor water quality, seasonal changes in habitat, and population pressures. NOAA Fisheries (2001) and CDFG (2002) have defined the high and low flow limits for each lifestage of the target fish for which passage should be accommodated at stream crossings. These flows have been defined in terms of annual exceedance flows obtained from flow duration curves derived from daily average flow records. The NOAA Fisheries and CDFG guidelines state that where daily flow duration data is available or can be synthesized, fish passage flows can be derived based on exceedance probabilities of gaged flows.

The high passage design flow for adult steelhead should be the 1% annual exceedance flow. For adult non--anadromous rainbow trout the high passage design flow should be the 5% annual exceedance flow, and the 10% annual exceedance flow for juvenile salmonids.

The low design flow for fish passage for adult salmonids is the 50% annual exceedance flow or 3 cfs, whichever is greater. For adult non anadromous salmonids the low passage design flow should be the 90% annual exceedance flow or 2 cfs, whichever is greater, and the 95% annual exceedance flow or 1 cfs whichever is greater for juvenile salmonids.

For this project, passage flows for juvenile trout, adult non-anadromous trout and adult anadromous steelhead were computed. Design flows were computed from a regional flow duration curve constructed using annual exceedance flows from five nearby gaged streams, scaled by unit drainage area and then averaged (**Table 2**).

Table 2 - Fish Passage Design Flow for Nissa-kah Creek at Nokomis Road, based on flow duration curves developed for five nearby stream gages

Species and Lifestage	Low Passage Design Flow	High Passage Design Flow
Juvenile Salmonids	**1.0 cfs**	**7.7 cfs** (10% Exceedance Flow)
Non-Anadromous Resident Fish	**2.0 cfs**	**16.1 cfs** (5% Exceedance Flow)
Adult Salmonids	**3.0 cfs**	**53.5 cfs** (1% Exceedance Flow)

2.2.2 Peak Recurrence Flows

A probabilistic flood frequency analysis using a Log Pearson Type III distribution was conducted using stream gage data from four nearby streams having similar drainage areas, topographic aspect, elevation, and rainfall. This analysis was completed using standard methods described in USGS Bulletin 17B, “Guidelines for Determining Flood Flow Frequency” (USGS, 1982). The peak flow per unit drainage area was calculated for each gage for the 1.2-year, 1.5-year, 2-year, 5-year, 10-year, 25-year, 50-year and 100-year return periods events. The flows were then scaled to the contributing drainage area of Nissa-kah Creek at the Nokomis Road crossing and then averaged.

An alternative method of estimating peak flows was also used. The USGS North Coast regional regression equations developed by Wananan and Crippen (1977) incorporate drainage area, mean annual precipitation and mean basin elevation as variables to predict peak flow in Northwestern California streams. The regression equations predict peak flows having 2-year, 5-year, 10-year, 25-year, 50-year and 100-year return periods.

The results of both methods are summarized in **Table 3** with supporting data and calculations found in **Appendix A.**

Table 3 - Predicted peak flows and associated return periods for Nissa-kah Creek at Nokomis Road

	Flow in cfs for the Return Period Indicated							
Method	**1.2 yr**	**1.5 yr**	**2 yr**	**5 yr**	**10 yr**	**25 yr**	**50 yr**	**100 yr**
Probabilistic analysis based on average of four gaged streams (USGS, 1982)	91	137	186	323	421	545	638	732
North Coast Regional Regression Equations (Waananen & Crippen, 1977)	-	-	139	225	306	405	509	588

Flows predicted from the probabilistic method were substantially larger than those predicted using the regression equations. For project design, results from probabilistic analysis were selected as a conservative estimate of peak flows. The peak design flow associated with a 100-year recurrence (Q_{100}) was selected for maintaining a stable channel bed. Other return intervals were used to assess the existing capacity of the culvert crossing. Additionally, the peak flow associated with the 1.5-year recurrence interval ($Q_{1.5}$) is commonly associated with the bankfull or channel forming flow, and was used to evaluate hydraulic conditions of the new channel. **For the project design Q_{100}, and $Q_{1.5}$ were estimated to be 732 cfs and 137 cfs, respectively.**

2.3 Step Pool Channel Configuration

2.3.1 Design Profile

The proposed channel consists of distinct steps and pools with an overall slope of 6.0% extending approximately 170 feet (**Figure 1**). The upstream ending elevation for the proposed channel was determined in part by the water surface elevation required to maintain suitable hydraulic conditions in the culvert. The elevation at the downstream end of the proposed roughened channel was based on the elevation of the existing channel and potential for future vertical channel adjustments (i.e. future channel degradation).

Large rock structures span the channel to create steps. Steps are spaced 13 feet apart and the drop between steps is set to be no more than 0.8 feet. This design provides a balance between (1) minimizing the length of the roughened channel to avoid downstream construction impacts and

(2) maintaining suitable fish passage conditions and bed stability within the constructed channel.

2.3.2 Culvert Outlet Sill

To provide sufficient depth and reduce velocity through the culvert during fish passage flows, an outlet sill will be installed onto the downstream edge of the apron. This sill can be constructed of wood, steel or concrete. The sill has a low flow V-notch in the center. Crest of the V-notch will be placed 0.9 feet above the apron and 0.4 feet above the rock step at the upstream end of the roughened channel.

2.3.3 Upstream Transition

The upstream end of the roughened channel was set at an elevation that would allow fish to leap onto the outlet apron, which will be submerged by the outlet sill. Because the culvert creates high exit velocities during large flows, a transition pool immediately downstream of the apron is incorporated into the design. This pool is sized 20 feet in length and with a residual depth of 2 feet to dissipate energy of the flow exiting the culvert.

2.3.4 Downstream Transitions

During large flood events velocities in the roughened channel can be higher than in the natural channel. It is important to incorporate a transition to slow the water and prevent excessive erosion of the downstream natural channel. Additionally, the downstream natural channel may adjust vertically through the design life of the project. Therefore, the design places the last three steps of the roughened channel below the existing grade of the channel. This will provide a transition to dissipate energy at the bottom of the roughened channel, and it will allow the roughed channel to continue functioning as designed even if the downstream channel incises as much as one foot.

2.3.5 Rock Steps

Rock steps consist of large rocks strategically placed to control the grade of the channel bed and create small steps in the water surface. Rock steps are permanent structures intended to maintain the roughened channel design grade, lead to formation pools, and facilitate fish passage. Rock steps consist of two rows of footer rocks and a single row of top rocks. The proposed roughened channel contains fourteen channel-spanning rock steps, similar in construction to rock weirs but placed within a matrix of stable engineered streambed material. The elevation difference between rock steps is 0.8 feet. The elevation difference is measured from the lowest point along the crest of each rock step, which is often located in the notch formed by contact between two rocks. All but one pair of the rock steps are spaced 13 feet apart; the spacing between the rock steps immediately upstream and downstream of the confluence with the Tha-Layla tributary is 17 feet. This is to create a longer pool to dissipate energy associated with the confluence of stream flows.

The proposed crest width at each rock step was set at 12 feet to produce the desired hydraulic conditions and to match the dimensions of the adjacent channel. To prevent flanking of the rock steps during large flows, the rock steps should be keyed at least 12 feet into the left bank (looking downstream) and floodplain. Along each rock step, the low point is in the center of the channel, with the crest sloping upwards towards the banks at a 6H:1V side-slope (**Figure 2**). This concentrates flows towards the center, creating slower, less turbulent waters along the edge of the channel. The side-slope across the rock step also creates plunging flow conditions along the edges that are well suited for juvenile salmonid passage.

Because the proposed channel slope is greater 6% to achieve the required vertical gain while remaining within the horizontal constrains, the rock steps are positioned perpendicular to the flowline rather than being arched or chevron shaped. Designing straight rock steps allows for closer spacing and steeper design slopes (CDFG, 2009). The cross-slope along the crest of the rock steps provides for limited concentration of flow towards the center of the channel, and banks and bed of a roughened channel are composed of engineered streambed material designed to resist erosion. Arch-shaped weirs, with the apex facing upstream are more often used as individual rock weirs, where native material comprises the channel bed and banks between the weirs. This weir shape further concentrates flow towards the center of the channel to protect the banks from erosion. However, this results in deeper scour pools and requires increased pool spacing.

2.3.6 Pools

Pools located between the rock steps are similar in size and shape as those found in natural step pool channels. The bottoms of the pools are composed of both large rock that is resistant to scour and smaller material that seals the voids (see Section 2.5.4 for rock sizing). These pools dissipate the energy of the plunging flow over each rock band. Additionally, they provide resting and potential rearing habitat for fish, and create suitable conditions for fish to leap. The depth and width of the pool bottom varies with the location along the profile, with a maximum residual pool depth of 2 feet (**Figures 3 and 4**).

2.3.7 Stream Banks

The stream banks along the edges of the active channel are constructed of various sized rock forming banklines. Similar to the conditions found in a naturally occurring steep stream channels, banklines are intended to be rigid and confine the channel. The top of the banks are located 3 feet above the thalweg, or flowline, at the rock step and vary along the length of the pool. The channel width at top-of-bank is roughly 16 feet. The channel is designed to contain flows slightly greater than the 1.5-year flow. At higher flows, the water begins to inundate an inset floodplain.

The existing floodplain along the left bank is broad and conveys a substantial portion of the streamflow. The existing floodplain along the right bank is not as uniform as the left bank but serves in a similar capacity. The newly graded portions of the floodplain will be covered with erosion control fabric and planted with native species. To reduce the risk of flanking, the rock steps will extend below final grade into the banks and across the graded floodplain. Additionally, any large wood salvaged from the project will be placed on the flood plain and anchored to create additional floodplain roughness.

2.3.8 Tributary Channel

Because the new channel is higher than the existing incised channel bed, the Tha-Layla Creek tributary will also require re-grading to provide positive flow into the main channel. The tributary channel will enter the new channel at the same elevation as the pool at station 12+50. The bankline of the new channel will conform to the tributary confluence. Approximately 40 feet of the tributary will be raised with engineered streambed material to match the grade of the new channel at the confluence. A rock step will be placed at the upstream end of the tributary section to provide grade control.

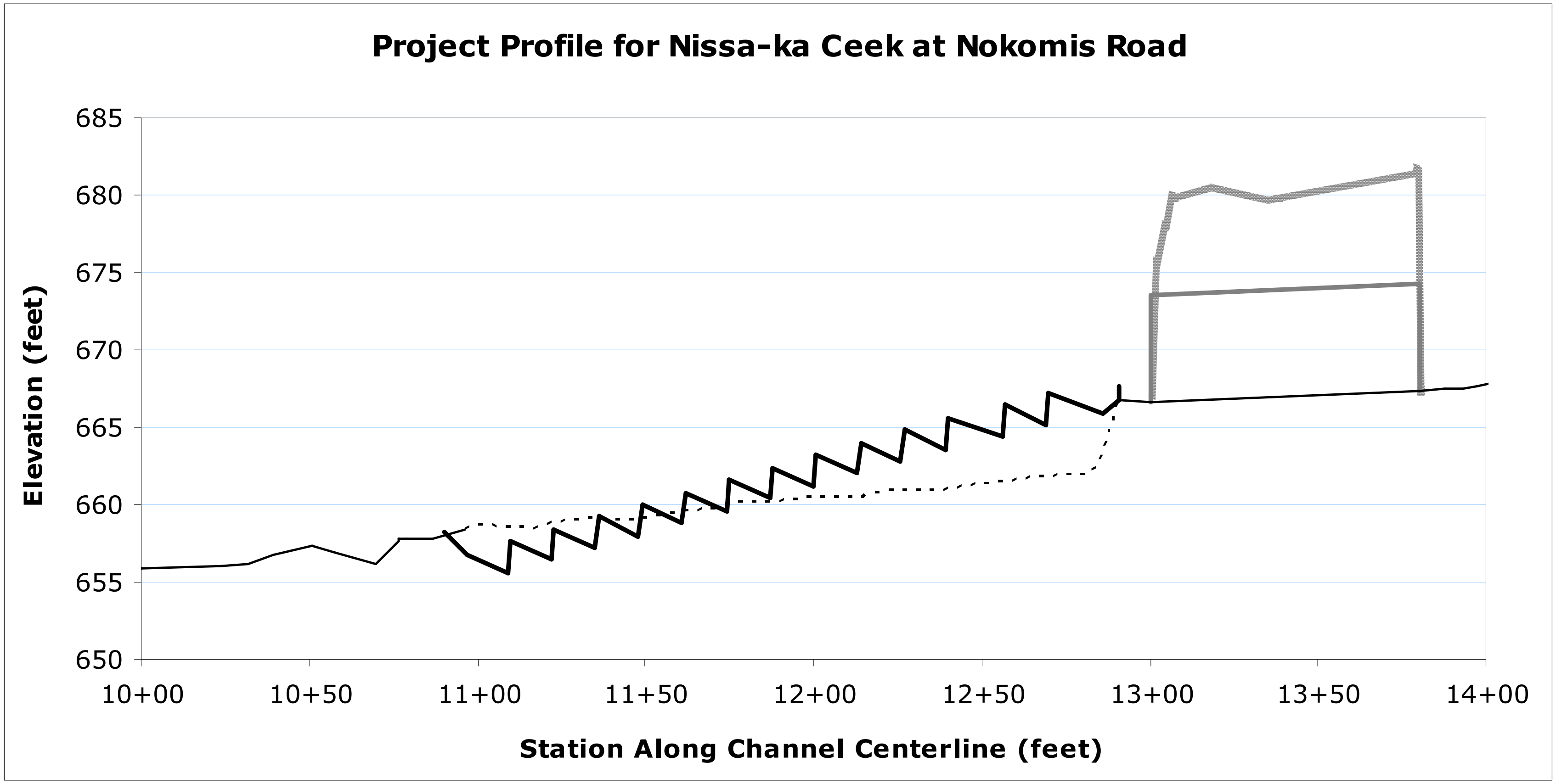


Figure 1 - Existing (E) and new (N) profile through the centerline of the proposed roughened channel. Roughened channel is at an overall slope of 6% for 170 feet.

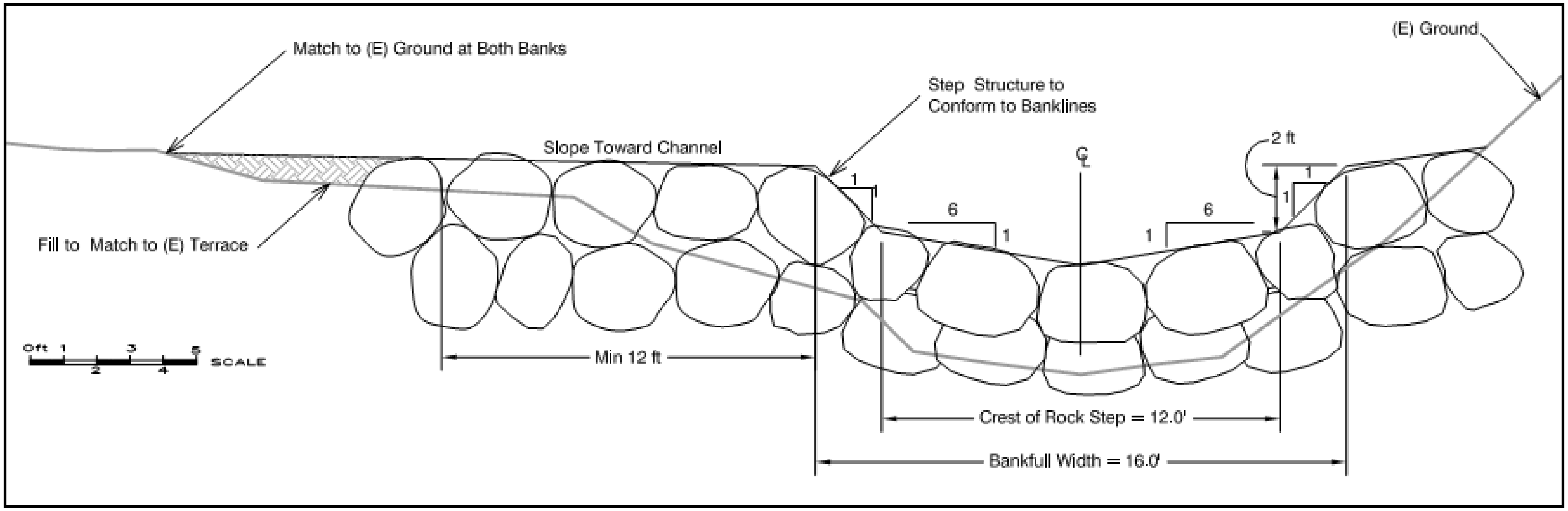


Figure 2 - Typical cross section at a rock step in the proposed channel for Nissa-kah Creek at Nokomis Road

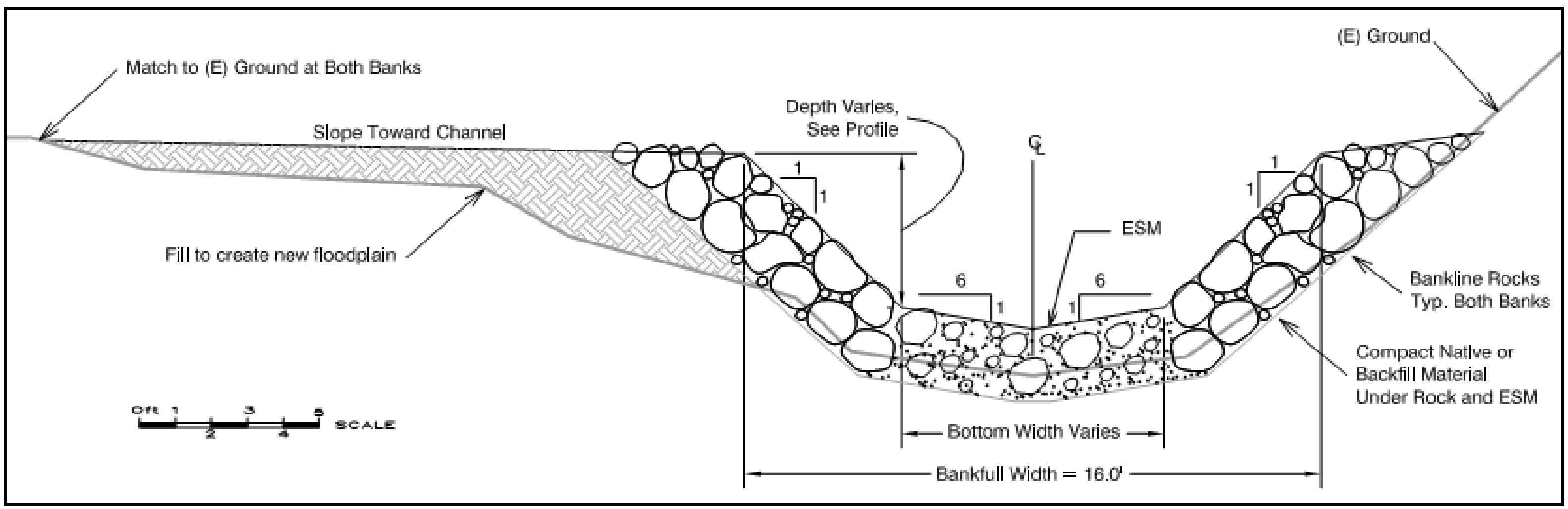


Figure 3 - Typical cross section at a pool in the proposed channel for Nissa-kah Creek at Nokomis Road.

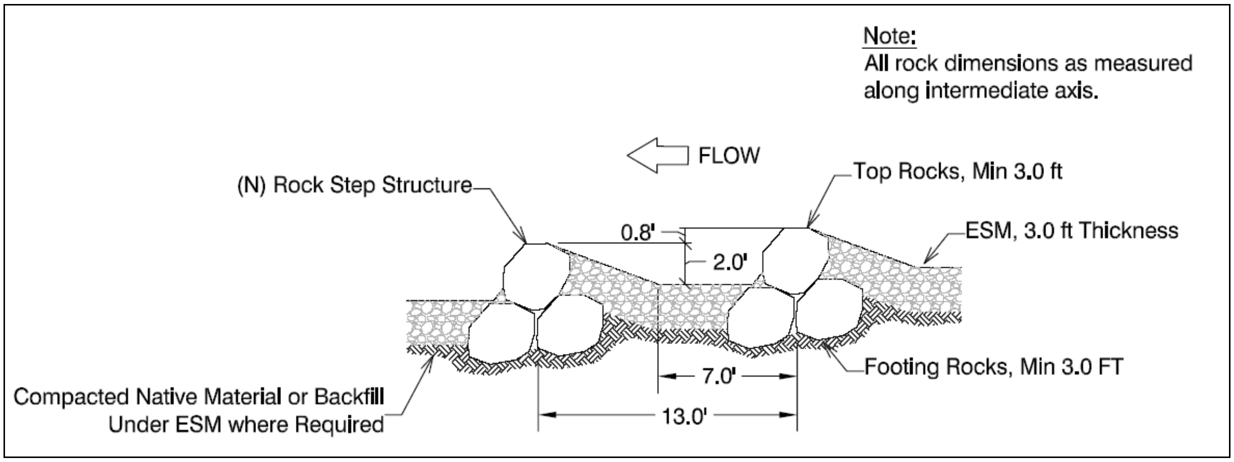


Figure 4 - Profile of typical step pool sequence with drop between steps of 0.8 feet, pool spacing of 13 feet and residual pool depth of 2 feet. A Non-woven geotextile fabric (not shown in the above figure) has been specified in the 90% complete plans for placement between the ESM and the compacted native subgrade material. The geotextile fabric will reduce the loss of stream flow through infiltration into the native subgrade during low flows.

2.4 Channel Hydraulics

At fish passage flows, the steps were assumed to form plunging flow and were modeled hydraulically as sharp crested weirs. At the 1.5-year flow and higher, the steps were modeled as a roughened chute assuming uniform flow conditions and a slope equal to the overall 6% slope of the roughened channel. At these high flows the controlling cross sectional shape of the channel was assumed to be the cross section at each step and hydraulic resistance, in the form of a Manning's roughness coefficient, was estimated based on depth dependent equations.

2.4.1 Hydraulic Roughness

The hydraulic roughness (Manning's coefficient) of the channel was estimated using a depth dependent equation that predicts roughness as a function of wetted channel geometry and particle size (Thorne and Zevenbergen, 1985). The size of the bed material in the roughened channel was determined through the bed stability analysis, as described below.

2.4.2 Hydraulic Conditions at Peak Flows

Table 4 summarizes the maximum water depth and average cross sectional water velocity over a typical step at 1.5-year and 100-year return period flows. **Figure 5** illustrates the water surface elevation at a step located approximately 100 feet downstream of the outlet apron. Based on the modeling at the 5-year flow and higher water velocities and shear stresses on the inset floodplain are relatively high. Therefore, erosion control fabric and roughness elements (i.e. anchored large wood) should be placed on the newly graded portions of the floodplain to reduce erosion and flanking. Similarly, the rock steps should be keyed well into the banks.

Table 4 - Hydraulic conditions across each step in the roughened channel below that Nokomis Road Crossing at the estimated 1.5 year and 100 year return period flows.

		Predicted Conditions	
Recurrence Interval	**Flow (cfs)**	**Water Depth (ft)**	**Water Velocity (ft/s)**
1.5 year	137	2.7	4.9
100 year	732	4.8	6.3

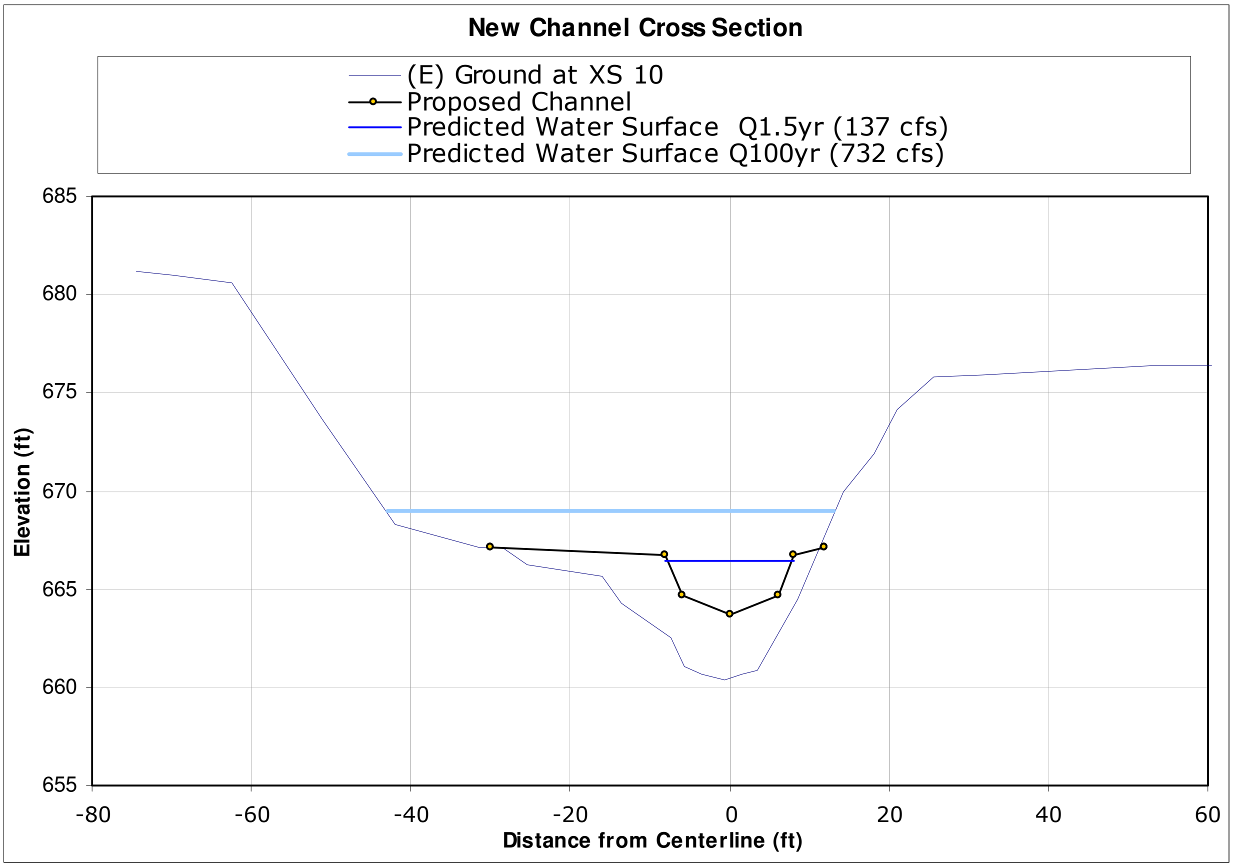


Figure 5 - Predicted water surface elevations at Q1.5 (137 cfs) and Q100 (732 cfs) at cross section 12+00, located across a step approximately 100 feet downstream of the culvert outlet apron.

2.5 Size and Gradation of Streambed Material

The streambed material for the main channel and the tributary channel is a well-graded mixture of rock and aggregate placed between rock steps that form the bed material of the roughened channel. The mixture is designed to:

(1) Maintain a stable bed up to the structural design flow by controlling scour of the streambed and banks

(2) Form a well compacted low-porosity bed to avoid subsurface flow, and

(3) Provide suitable flow characteristics to create the desired velocity and depth conditions for fish passage.

2.5.1 Bed Stability Analysis

A bed stability analysis determined the size of rock necessary to maintain a stable channel bed and banks at flows up to the 100-year design flow (Q_{100}) of 732 cfs in the creek. The stability analysis is an iterative process involving the interdependent variables of particle size, channel roughness, and channel hydraulic geometry. The stability analysis assumed uniform flow and a water surface slope during the 100-year peak flow equal to the overall slope of the roughened channel.

Sizing the bed material follows the unit discharge (flow divided by channel width) based approach outlined in the US Army Corps of Engineers (ACOE) Steep Slope Riprap Design (ACOE, 1994). As a conservative estimate of unit discharge within the channel, floodplain flow conveyance was assumed negligible. This method predicts the diameter, measured along the intermediate axis, of a stable particle size. The ACOE riprap design procedure returns a relatively uniform gradation of rock sizes resulting in a porous bed. A porous bed leads to subsurface flow, which is undesirable for fish passage. The *Design of Road Culverts for Fish Passage* (WDFW, 2003) and CDFG (2009) recommends using a D_{84} (84% of the material in the mixture is smaller than the D_{84}) that is 1.5 times larger than the stable particle size predicted using the ACOE method. Once the D_{84} is calculated, the D_{50} can be determined using methods outlined in WDFW (2003) and CDFG (2009). The methodology for determining the D_{100} can return an infeasible rock size. Therefore, engineering judgment is often used to determine an appropriate D_{100}. The gradation of particle sizes smaller than the D_{50} is determined using a modified Fuller-Thompson equation, which produces a low porosity mixture (USFS, 2008). The result is the engineered streambed material.

2.5.2 Engineered Streambed Material for Channel Reach

The bed stability analysis methodology, described in the previous section, determined the gradation of the engineered streambed material (ESM) for the entire reach. The gradation, presented **Table** 5**,** indicates that 8% of the ESM is smaller than 2 millimeters (D_8), 32% is smaller than 4 inches (D_{32}), 50% is smaller than 11 inches (D_{50}), 84% is smaller than 26 inches (D_{84}), and 100% is smaller than 48 inches (D_{100}). As mentioned in the bed stability analysis section, the methodology for determining the D_{100} can result in an infeasible rock size. For this project, the methodology results in a D_{100} particle size of 5.4 feet, which is not feasible. Using engineering experience and judgment, a diameter of 4 feet was selected for D_{100} for channel ESM.

Table 5-Channel Reach Engineered Streambed Material Gradation

Percent Finer	**8**	**32**	**50**	**84**	**100**
Particle Diameter*	< 2mm (sands and silts)	4 inch	11 inch	26 inch	48 inch

* Diameter is measured along the intermediate axis

2.5.3 Size of Rock for Rock Steps

The rock steps are permanent structures intended to maintain the roughened channel design grade, lead to the formation of pools, and facilitate fish passage. The rock steps are composed of the largest material in the gradation, typically rock between the D_{84} and D_{100} particle sizes. For this application, it is recommended that the rocks within the rock steps range between 3 feet and 4 feet. This rock size is consistent with guidance provided in NRCS's publication on rock weir design (Castro, 2000). This generally falls into the CalTrans standard 2-ton rock size class.

2.5.4 Engineered Streambed Material Gradation Between Rock Steps

The ESM gradation specified above in **Table 5** accounts for the larger rocks that comprise the rock steps. Eliminating the portion of the ESM gradation that accounts for the rock steps results in an adjusted gradation that represents the ESM to be placed between the rock steps as specified in **Table 6**.

Table 6 - Final design gradation for engineered streambed material between rock steps (ESM), percent by volume.

Percent by Volume	**Rock Diameter* Range (inch)**	
	Smallest	Largest
16	20	26
16	12	20
16	6	12
18	4	6
24	#8 sieve (2.38 mm)	4
8	<#10 sieve (2 mm)	

* Diameter is measured along the intermediate axis

2.5.5 Thickness of Engineered Streambed Material

Consistent with standard guidance provided by ACOE (1994), the thickness of the engineered streambed material of 3 feet was utilized between the rock steps and was increased to 4 feet in the entrance pool.

2.5.6 Compaction and Sealing of the Bed

The finer material, smaller than the D_{50}, is sized to seal the bed and minimize subsurface flow. A non-woven geotextile fabric placed between the ESM and the native subgrade material for the full length and width of the new channel will also reduce subsurface flow. The ESM should be well-graded during placement to ensure the smaller material fills the voids between the larger rocks. The ESM should be mechanically tamped during placement to achieve suitable compaction. Once in place, the ESM should be flooded or jetted as a final step in the compaction process. This helps work the fine material into any remaining voids within the bed. If the pools drain rapidly during flooding, additional fine material (sands and silts) may need to be added to the surface between steps and then jetted into the bed. This process is repeated until jetted water remains on the surface of the ESM.

2.6 Bankline Rock Material

The streambanks, or banklines, of the roughened channel are constructed with a mixture of rock intended to be rigid and resist erosion. For this application, it is recommended that the bankline rock be ¼ ton rock individually placed with facing class rock to fill the large voids. Once placed, smaller rock should then be used to fill the remaining voids using the techniques presented in Section 2.5.6.

3.0 FISH PASSAGE CONDITIONS OF PROPOSED DESIGN

The roughened channel design creates hydraulic conditions that should allow passage of all size classes of salmonids throughout the range of fish passage design flows.

3.1 Fish Passage Criteria

CDFG and NOAA Fisheries have fish passage guidelines that state specific criteria for both adult and juvenile salmonids. To provide unimpeded adult and juvenile passage, these fish passage criteria should be satisfied between the low and high fish passage design flows. However, CDFG and NOAA Fisheries guidelines recognize the criteria cannot always be satisfied when retrofitting an existing culvert, and suggest they be applied as a project goal rather than a strict requirement.

3.1.1 Criteria for Step Pool Roughened Channels

For a step pool roughened channel several design criteria apply. CDFG recommends a maximum drop of 1 foot for rock weirs. NOAA Fisheries recommends minimum depth criteria for jump pools below hydraulic drops of 1.5 times the drop height or 2 ft, whichever is deeper.

Excessive turbulence associated with the dissipation of energy can also create a barrier to upstream migrating fish. Turbulence can be evaluated by calculating the energy dissipation factor (EDF), which is a measure of the rate of energy dissipated divided by the volume of water in the pool below the plunge. Although there are no specific criteria for excessive turbulence, the WDFW Fish Passage at Stream Crossings Design Manual (2003) and CDFG (2009) recommends using a maximum EDF of 4 ft-lb/s/ft^3 for pool and weir fishways at the high passage flow for adult salmon and steelhead. A higher threshold is often acceptable for roughened channels because of the hydraulic diversity provided by the multiple pathways and the variegated surface provided by the engineered streambed material and large rock structures. Because this project is designed as a step pool channel and functions similar to a pool and weir fishway an EDF threshold of 4 ft-lb/s/ft^3 was used to guide the sizing of the pools.

3.1.2 Criteria for Culvert Retrofits

For improving hydraulic conditions inside culverts, CDFG and NOAA Fisheries prescribe minimum water depths and maximum average water velocities for both adult steelhead and juvenile salmonids. CDFG also has guidelines for adult resident rainbow trout. Velocity criteria are dependent on the length of the culvert (**Table 7**). Additionally, both recommend a maximum water surface drop of 6 inches at the outlet of a culvert for juvenile salmonids and 1 foot for adult steelhead.

3.2 Fish Passage Conditions in the Step Pool Roughened Channel

At fish passage flows the flow is characterized by plunges as it drops over steps and into pools. Hydraulic conditions were predicted using standard sharp-crested weir flow equations (King, 1939) that account for the weir shape and submergence from backwatering of the step.

Predicted water surface drop, pool depth and energy dissipation factors (EDF) at the low and high passage design flows are listed in **Tables 8** and **Table 9**.

3.2.1 Pool Depth

At the low passage design flows water depth is based on the depth of the pools between each rock step. The pools are designed to be a minimum 2.0 ft deep, as recommended by the NOAA Fisheries guidelines. As flows increase, the water depth in the pool increases. The pool depth, as designed, should be sufficient for upstream and downstream passage of all age classes of salmonids present at the low passage design flows. Additionally, these pools may provide rearing habitat for salmonids during portions of the years.

3.2.2 Turbulence and Energy Dissipation

EDF in each pool was determined using methods described in WDFW (2003). EDF reaches 4.0 ft-lb/s/ft^3 at about 42 cfs. While the EDF at the adult steelhead high passage design flow is 4.6 ft-lb/s/ft^3, there will likely exist less turbulent water along the edges of the pools that the fish can utilized.

Table 7 - CDFG and NOAA Fisheries fish passage depth and velocity criteria. Velocity criteria are for culverts between 60 and 100 ft long.

Species and Lifestage	Minimum Water Depth	Max. Water Velocity (distance 60 – 100 ft)
Juvenile Salmonids	0.50 ft	1 ft/s
Adult Rainbow	0.67 ft	4 ft/s
Adult Steelhead	1.00 ft	5 ft/s

Table 8 - Low Passage Design Flow. Hydraulic conditions in the roughened channel below Nokomis Road Crossing.

		Predicted Conditions		
Low Passage Design Flow	**Flow (cfs)**	**Water Surface Drop (ft)**	**Maximum Pool Depth (ft)**	**EDF (ft-lb/s/ft^3)**
Juvenile Salmonid	1.0	0.78	2.4	0.2
Adult Resident Trout	2.0	0.78	2.5	0.4
Adult Steelhead	3.0	0.78	2.6	0.6

Table 9 - High Passage Design Flow. Hydraulic conditions in the roughened channel below Nokomis Road Crossing.

		Predicted Conditions		
High Passage Design Flow	**Flow (cfs)**	**Water Surface Drop (ft)**	**Maximum Pool Depth (ft)**	**EDF (ft-lb/s/ft^3)**
Juvenile Salmonid	7.7	0.78	2.8	1.4
Adult Resident Trout	16	0.78	3.1	2.1
Adult Steelhead	53	0.78	3.9	4.6

3.3 Culvert Fish Passage Conditions

To improve passage through the culvert we propose to install a sill onto the downstream edge of the concrete outlet apron. The sill will create a backwater in the culvert to increase depth and reduce velocity. The sill is designed to work in conjunction with the step pools and maintain a drop of less than 0.5 feet at the outlet during fish passage flows.

Water depths over the proposed outlet sill were predicted using standard equations for sharp crested compound shaped weirs (King, 1939). The first downstream rock step is positioned such that it begins to submerge the outlet sill at approximately 2 cfs. At fish passage flows above 2 cfs the flow calculation for the sill was adjusted using a submergence ratio (Villemonte, 1947).

Figure 6 illustrates the water surface profile across the outlet apron sill and over the first two steps downstream of the apron.

Using the predicted water depth over the sill at the various fish passage flows, conditions in the culvert were predicted using the FishXing 3.0 software and are summarized in **Tables 10** and **Table 11**.

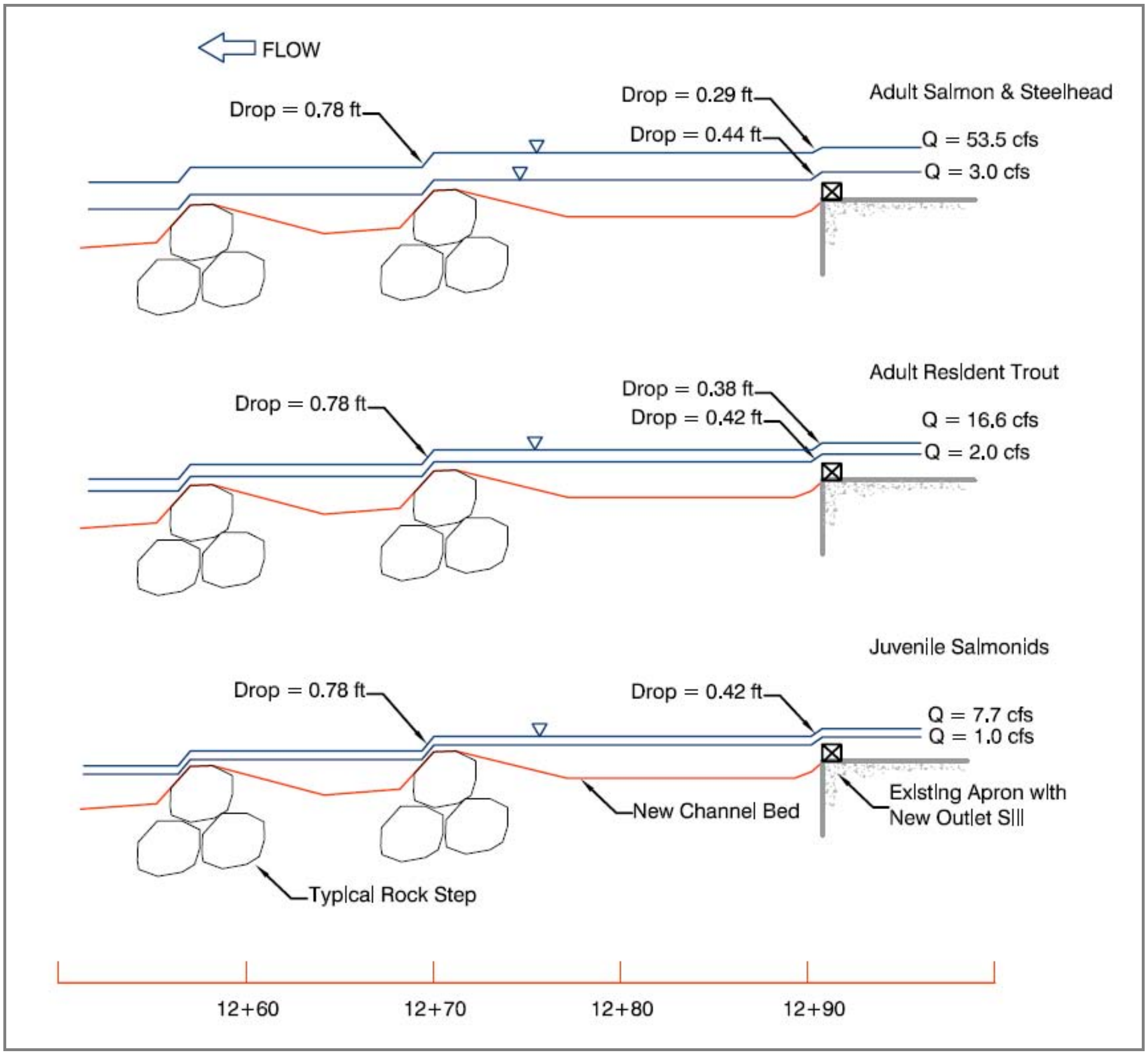


Figure 6 - Predicted water surface profiles over the outlet sill and rock steps at each fish passage design flow.

3.3.1 Water Depths

The proposed design, with the outlet sill functioning as a weir, meets depth criteria for juvenile salmonids and adult resident rainbow trout. At the adult steelhead low passage design flow of 3 cfs water depth in the vicinity of the culvert inlet is 0.93 feet, which is slightly lower than the criteria. However, in most of the culvert and on the apron the depth is greater than one foot.

These depths are more than adequate to fully submerge an adult steelhead as it swims through the culvert.

3.3.2 Water Velocities

Water velocities within the culvert are predicted to be less than the criteria at the high passage design flows for all lifestages.

Table 10 - Low Passage Design Flow Inside Culvert. Existing and proposed water velocities and depths in the Nissa-kah culvert at Nokomis Road.

		Existing Conditions[1]			Proposed Conditions[2]		
Low Passage Flow Condition	**Flow (cfs)**	**Min. Depth (ft)**	**Max. Velocity (ft/s)**	**Outlet Drop (ft)**	**Min. Depth (ft)**	**Max. Velocit y (ft/s)**	**Outlet Drop (ft)**
Juvenile Salmonids	1.0	0.09	2.26	4.68	0.70	0.23	0.42
Adult Resident Trout	2.0	0.14	2.96	4.63	0.81	0.39	0.42
Adult Steelhead	3.0	0.18	3.39	4.61	0.93	0.53	0.44

[1] Existing conditions determined from modeling using FishXing 3.0.
[2] Proposed conditions with outlet sill attached to concrete outlet apron.

Table 11 - High Passage Design Flow Inside Culvert. Existing and proposed water velocities and depth in the Nissa-kah culvert at Nokomis Road.

		Existing Conditions[1]			Proposed Conditions[2]		
High Passage Flow Condition	**Flow (cfs)**	**Min. Depth (ft)**	**Max. Velocity (ft/s)**	**Outlet Drop (ft)**	**Min. Depth (ft)**	**Max. Velocity (ft/s)**	**Outlet Drop (ft)**
Juvenile Salmonids	7.7	0.32	4.64	4.57	1.16	1.09	0.42
Adult Resident Trout	16.1	0.5	5.89	4.55	1.40	1.90	0.38
Adult Steelhead	53.5	1.10	8.67	4.69	2.17	4.08	0.29

[1] Existing conditions determined from modeling using FishXing 3.0.
[2] Proposed conditions with outlet sill attached to concrete outlet apron.

4.0 CULVERT HYDRAULIC CAPACITY

4.1 Existing Hydraulic Capacity

The Federal Highway Administration hydraulic model HY-8 was used to estimate capacity of the existing culvert at the flow that submerges the culvert soffit, (Headwater Depth/Culvert Rise = 1). The following assumptions were applied to the model; inlet conditions were defined as Square Edge with (30^0-75^0 flare) Wingwall , a Manning's n roughness coefficient of 0.013, and a constant tailwater elevation based on the assumption of inlet control hydraulics.

Results of this analysis were checked against Chart 8 in HDS-5 (US Dept of Transportation, 1985). We found that the existing crossing has a capacity of approximately 330 cfs and is characterized as having inlet control hydraulics. This flow corresponds to the 5-year return flow as defined by the peak flow analysis described above. We also found that the road becomes overtopped at a flow of 665 cfs, which corresponds to a flow with a return period between 50 and 100-years.

4.2 Hydraulic Capacity with Proposed Retrofit

To assess the capacity of the crossing with the addition of the outlet sill and new step pool channel, we conducted a similar analysis to determine existing conditions. A tailwater rating curve was developed for the proposed outlet conditions. Because the outlet sill is completely submerged by the downstream step at capacity flows, we assumed that the upstream end of the new step pool channel would provide the tailwater control for the culvert. The depth over the upstream most step was calculated assuming uniform flow over the upper step, as described in the bed stability analysis section above.

Two flows were examined to assess capacity of the proposed project: the 5 year return period flow of 330 cfs that represents the current capacity and 665 cfs, which represents the flow at which Nokomis Road is currently overtopped. Using HY-8 we found the culvert remained inlet controlled and the headwater elevation was unchanged when compared to the existing conditions. **This project is anticipated to have no impact on existing capacity of the culvert or upstream water surface elevations during flood flows.**

5.0 OPINION OF PROBABLE CONSTRUCTION COST

An opinion of probable construction cost was developed for the project and has been tabulated in Appendix D. The table contains an itemized list of probable unit construction costs in addition to an estimating contingency. An estimating contingency accounts for material and construction cost volatility. The construction costs are based on current construction and material costs. Predicting material costs and the bidding climate when the project is bid is difficult and therefore the unit costs were not inflated or adjusted for future value.

In addition to developing opinion of probable construction costs, the opinion of probable cost associated with preparation of the final bid package, which would include final construction plans, specifications, and the construction cost estimate has also been included in Appendix D. Opinion of probable costs were also developed and presented in the table for bidding assistance and construction management. The cost associated with construction management assumes prevailing wage labor rate for onsite inspection during construction.

6.0 CONCLUSIONS

To improve fish passage at the Nokomis Road crossing, we propose to raise the channel to the culvert outlet with a 170-foot long step pool roughened rock channel. It would be constructed at an overall slope of 6% that would be comprised of a series of steps with distinct pools. It would have a crest width of 12 feet at the steps and a top of bank width of 16 feet along the entire reach. The bed of the new channel is designed as an engineered mixture of different rock sizes intended to be stable up to the 100-year design flow of 732 cfs and provide sufficient roughness and complexity to provide for passage of fish and other aquatic species. The upstream portion of the channel will be positioned to work in conjunction with an outlet sill to increase depth and slow water velocities in the box culvert. The project will provide a large improvement in upstream passage conditions for all lifestages of steelhead/rainbow trout.

7.0 REFERENCES

California Department of Fish and Game. 2002. *Culvert criteria for fish passage*. 17 pages.

California Department of Fish and Game. 2009. *Fish Passage Desgin and Implementation. Part XII of the California Salmonid Stream Habitat Restoration Manual. 188 pages.*

Castro, J. (2000). Design of Rock Weirs, Technical Notes Engineering No. 24. Portland, OR, U.S. Department Of Agriculture, Natural Resources Conservation Service.

Federal Highway Administration, 2007. Hydraulic Design Series–5, Hydraulic Design of Highway Culverts, HY-8 Version 7.0 software.

King, H.W. 1939. Handbook of Hydraulics, Third Edition, McGraw Hill Book Company

Montgomery, D. R. and J. M. Buffington. 1997. "Channel-reach morphology in mountain drainage basins." Geological Society of America Bulletin 109: 596-611.

National Marine Fisheries Service. 2001. Guidelines for salmonid passage at stream crossings. NMFS SW Region. 14 pages.

Saldi-Caromile, K., K. Bates, et al. (2004). Stream Habitat Restoration Guidelines: Final Draft., Co-published by the Washington Departments of Fish and Wildlife and Ecology and the U.S. Fish and Wildlife Service.

Taylor, Ross. 2008. Habitat Typing Surveys of Russian River Tributaries located on the Hopland Bank of Pomo Indians Reservation, Draft. Ross Taylor and Associates. 26 pages

Taylor, Ross. 2006. *Hopland Band of Pomo Indian Reservation Stream Crossing Inventory and Fish Passage Evaluation.* Prepared for the Hopland Band of Pomo Indians' EPA Division.

Thorne, C. and L. Zevenbergen. 1985. Estimating mean velocity in mountain rivers. *J. of Hydraulic Engineering*, ASCE, Vol. 111, No. 4, pp. 612-624.

USFS. 2007. FishXing 3.0 beta software. US Forest Service. http://fishxing.org.

USFS. 1998. WinXSPRO, A Channel Cross Section Analyzer, User's Manual, Version 3.0 Gen. Tech. Rep. RMRS-GTR-147. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station. 95 p.

USFS. 2008. Stream simulation: An ecological approach to providing passage for aquatic organisms at road-steram crossings. US Forest Service, San Dimas Technology Center. 087-1801-SDTDC, May 2008.

USGS. 1982. *Guidelines for Determining Flood Flow Frequency.* Bulletin 17B of Hydrology Subcommittee, Interagency Advisory Committee on Water Data, US Dept. of Interior Geological Survey, Reston Virginia.

U.S. Army Corps of Engineers. 1994. Hydraulic Design of Flood Control Channels, June 30, 1994. EM 1110-2-1601.

Washington Department of Fish and Wildlife Environmental Engineering Division (WDFW). 2003. *Fish passage design at road culverts: a design manual for fish passage at road crossings*. May 2003. http://www.wa.gov/wdfw/hab/engineer/cm/.

Waananen, A.O. and J.R. Crippen. 1977. Magnitude and frequency of floods in California. U.S. Geological Survey, Water Resources Investigation 77-21, Menlo Park, CA. 96 p.

Villemonte, J.R. 1947. Submerged weir discharge studies. *Engineering News Record*, 866, Dec.

Personal Communications

Taylor, Ross, Ross Taylor and Associates, McKinleyville CA 707-839-5022

Appendix A
Hydrologic Calculations

USGS Gaged Streams near the Nokomis Road at Nissa-Kah Creek crossing. Exceedance flows are given in per unit drainage area.

Station Number	Station Name	Drainage Area (sq. miles)	Record Length (years)	Coverage (WY)	H (Altitude Index per 1,000 ft)	P (Precipitation (in/yr))	Latitude	Longitude
11467850	SODA C TRIB NR BOONVILLE CA	1.53	4	1964-1968	1.2	40	39.02545	-123.2913963
11448500	ADOBE C NR KELSEYVILLE CA	6.36	24	1954-1978	2.1	41	38.92684	-122.8808283
11448900	HIGHLAND C AB HIGHLAND C DAM CA	11.9	16	1962-1978	1.9	37	38.91962	-122.9208298
11464050	DRY C TRIB NR HOPLAND CA	1.19	2	1967-1969	1.4	48	38.88601	-123.1552822
11473980	GOFORTH C A DOS RIOS CA	3.83	3	1965-1968	2	45	39.712	-123.342514
	Summary - Average of exceedance flows							
	Nissa-Kah flows							

Criteria for determining fish passage flows at stream crossings

	Exceedance Flows	
Species and Age Class	**Lower Fish Passage Flow ***	**Upper Fish Passage Flow**
Adult Anadromous Salmonids	50% EP or 3 cfs	1%
Non-Anadromous Adult Salmonids	90% EP or 2 cfs	5%
Juvenile Salmonids	95% EPor 1 cfs	10%

* Use the greater of the two for determining the lower fish passage flow

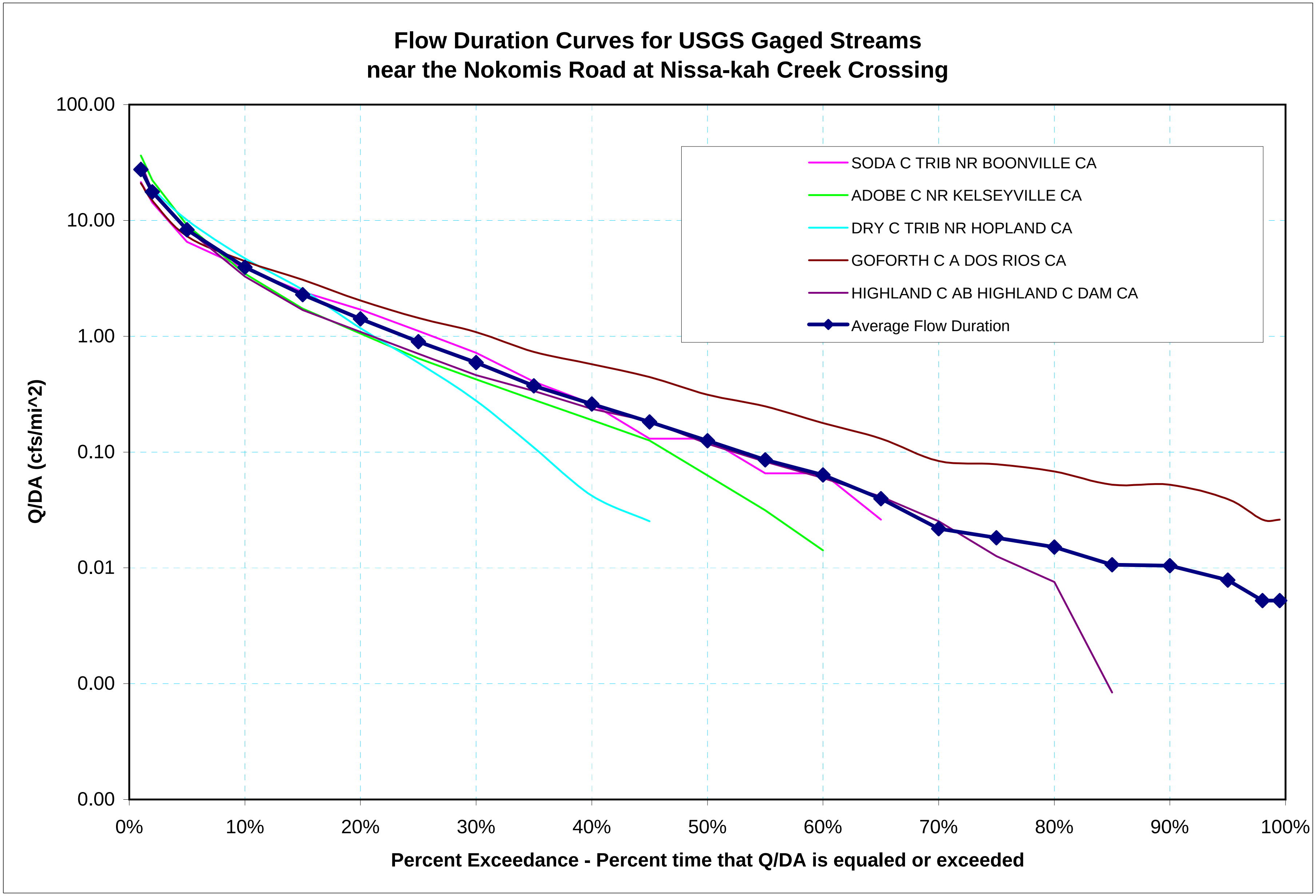
Nokomis Road at Nissa-Kah crossing **1.94** **sq mi**

	Exceedance Flows	
Species and Age Class	**Lower Fish Passage Flow (cfs)**	**Upper Fish Passage Flow (cfs)**
Adult Anadromous Salmonids	3	53.5
Non-Anadromous Adult Salmonids	2	16.1
Juvenile Salmonids	1	7.7

**Fish Passage flows at the Nokomis Road at Nissa-Kah Creek crossing based on average exceedance flows from 5 local stream gages and normalized by drainage area.*

Flow Duration Table for Gaged Streams within and near the Nokomis Road crossing at Nissa-kah creek project site . The average of the exceedance flows is used to estimate the fish passage flows.

Percent Time Flow is Equalled or Exceeded	SODA C TRIB NR BOONVILLE CA	ADOBE C NR KELSEYVILLE CA	HIGHLAND C AB HIGHLAND C DAM CA	DRY C TRIB NR HOPLAND CA	GOFORTH C A DOS RIOS CA	Minimum Flow	Maximum Flow	Average Flow	Minimum Flow at Nissa-Ka Ck	Maximum Flow at Nissa-Ka Ck	Average Flow at Nissa-Ka Ck
	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	(cfs/mi^2)	cfs	cfs	cfs
1%	21.438	36.376	31.548	27.479	20.940	20.940	36.376	27.556	40.623	70.569	53.459
2%	14.248	22.280	17.647	19.160	14.883	14.248	22.280	17.643	27.642	43.223	34.228
5%	6.536	9.119	8.403	10.084	7.311	6.536	10.084	8.291	12.680	19.563	16.084
10%	3.856	3.459	3.277	4.706	4.439	3.277	4.706	3.947	6.358	9.129	7.658
15%	2.418	1.730	1.681	2.521	3.068	1.681	3.068	2.283	3.261	5.952	4.430
20%	1.699	1.053	1.092	1.176	2.037	1.053	2.037	1.412	2.044	3.951	2.739
25%	1.111	0.645	0.706	0.588	1.436	0.588	1.436	0.897	1.141	2.786	1.741
30%	0.719	0.425	0.462	0.277	1.084	0.277	1.084	0.593	0.538	2.102	1.151
35%	0.405	0.283	0.336	0.109	0.731	0.109	0.731	0.373	0.212	1.418	0.724
40%	0.261	0.189	0.235	0.042	0.574	0.042	0.574	0.260	0.082	1.114	0.505
45%	0.131	0.126	0.185	0.025	0.444	0.025	0.444	0.182	0.049	0.861	0.353
50%	0.131	0.063	0.118	0.000	0.313	0.000	0.313	0.125	0.000	0.608	0.242
55%	0.065	0.031	0.083	0.000	0.248	0.000	0.248	0.085	0.000	0.481	0.166
60%	0.065	0.014	0.060	0.000	0.178	0.000	0.178	0.063	0.000	0.344	0.123
65%	0.026	0.000	0.041	0.000	0.131	0.000	0.131	0.040	0.000	0.253	0.077
70%	0.000	0.000	0.025	0.000	0.084	0.000	0.084	0.022	0.000	0.162	0.042
75%	0.000	0.000	0.013	0.000	0.078	0.000	0.078	0.018	0.000	0.152	0.035
80%	0.000	0.000	0.008	0.000	0.068	0.000	0.068	0.015	0.000	0.132	0.029
85%	0.000	0.000	0.001	0.000	0.052	0.000	0.052	0.011	0.000	0.101	0.021
90%	0.000	0.000	0.000	0.000	0.052	0.000	0.052	0.010	0.000	0.101	0.020
95%	0.000	0.000	0.000	0.000	0.039	0.000	0.039	0.008	0.000	0.076	0.015
98%	0.000	0.000	0.000	0.000	0.026	0.000	0.026	0.005	0.000	0.051	0.010
99.5%	0.000	0.000	0.000	0.000	0.026	0.000	0.026	0.005	0.000	0.051	0.010



Michael Love &Associates
PO Box 4477 Arcata CA 95518

Peak Flow Calculation Summary
Nissa-Kah Ck at Nokomis Rd

Method	Q-1.2 yr (cfs)	Q-1.5 yr (cfs)	Q-2 yr (cfs)	Q-5 yr (cfs)	Q-10 yr (cfs)	Q-25 yr (cfs)	Q-50 yr (cfs)	Q-100 yr (cfs)
LP III Analysis of USGS Stream Gaging Records, average of 4 sites	**91**	**137**	**186**	**323**	**421**	**545**	**638**	**732**
Waananen & Crippen, 1977 (North Coast)			139	225	306	405	509	588

* Estimates using regional regression equations developed for the North Coast Region of California by the USGS (Waananen and Crippen, 1977):

North Coast Region

$$Q2 = 3.52\, A^{0.90}\, P^{0.89}\, H^{-0.47}$$
$$Q5 = 5.04\, A^{0.89}\, P^{0.91}\, H^{-0.35}$$
$$Q10 = 6.21\, A^{0.88}\, P^{0.93}\, H^{-0.27}$$
$$Q25 = 7.64\, A^{0.87}\, P^{0.94}\, H^{-0.17}$$
$$Q50 = 8.57\, A^{0.87}\, P^{0.96}\, H^{-0.08}$$
$$Q100 = 9.23\, A^{0.87}\, P^{0.97}$$

A = drainage area (mi2),
p = mean annual precipitation (in/yr),
H = Altitude index in thousands of feet

Mean annual precipitation was obtained from Parameter-elevation Regressions on Independent Slopes Model (PRISM). Data set provided by Oregon Climate Service (OCS) mapping program.

A (drainage area) = 1.94 mi^2
H (mean elevation of main channel (1000-ft). If less than 1000 ft, H = 1) = 1.5 from Hopland USGS quad
P (mean annual precipitation) = 40 in/yr from Prism

DS 10% elev = 765 feet
US 85% elev = 2300 feet

Log Pearson Type III Probabilistic Analysis
Nissa-kah Creek at Nokomis Road

Flow Gaging Station	Drainage Area (mi^2)	Length of Record (Years)	Precip	Alt Index	Recurrence Interval of Unit Peak Flows (Years) 1.2 (cfs/mi^2)	1.5 (cfs/mi^2)	2 (cfs/mi^2)	5 (cfs/mi^2)	10 (cfs/mi^2)	25 (cfs/mi^2)	50 (cfs/mi^2)	100 (cfs/mi^2)
ALDER C NR POTTER VALLEY CA	1.39	8	45	2.7	31.0	51.8	74.9	140.7	190.5	247.9	292.2	335.3
SODA C TRIB NR BOONVILLE CA	1.53	9	40	1.2	44.3	59.9	76.2	122.7	158.4	209.0	250.6	295.6
SF STONY C NR STONYFORD CA	2.52	9			65.4	88.2	111.2	173.1	217.5	276.9	323.1	371.0
HIGHLAND C AB HIGHLAND C DAM CA	11.9	23	37	1.9	47.1	82.3	121.4	229.3	302.2	389.9	450.5	506.4
Average Discharge per Sq. Mi. (cfs/mi^2)					**46.9**	**70.6**	**95.9**	**166.5**	**217.2**	**280.9**	**329.1**	**377.1**
Min. Discharge per Sq. Mi. (cfs/mi^2)					31.0	51.8	74.9	122.7	158.4	209.0	250.6	295.6
Max. Discharge per Sq. Mi. (cfs/mi^2)					65.4	88.2	121.4	229.3	302.2	389.9	450.5	506.4

Drainage Area (mi^2)	Precip	Alt Index	**Nissa-kah Creek at Nokomis Road** Recurrence Interval of Peak Flows (cfs) 1.2 (cfs)	1.5 (cfs)	2 (cfs)	5 (cfs)	10 (cfs)	25 (cfs)	50 (cfs)	100 (cfs)
1.94	40	1.5	**91**	**137**	**186**	**323**	**421**	**545**	**638**	**732**

Average discharge per sq. mi from above gages

Flood Frequency based on Annual-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	Altitude	Drainage (sq mi)	Daily flow data count	Peak flow data count
11470700	ALDER C NR POTTER VALLEY CA	39.38877305	-123.04	NAD83		1.39		9

Flood Frequency based on Annual Maximum Series

Annual Maxima Series

WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
	1/23/1970	250	1	9.00	250	7.08	2.40
	1/31/1963	149	2	4.50	149	4.22	2.17
	12/23/1968	140	3	3.00	140	3.96	2.15
	12/3/1970	140	4	2.25	140	3.96	2.15
	1/20/1964	122	5	1.80	122	3.45	2.09
	1/16/1973	105	6	1.50	105	2.97	2.02
	1/30/1968	42	7	1.29	42	1.19	1.62
	1/22/1972	19	8	1.13	19	0.54	1.28

Sample Size, n =	8		
Skewness =	0.34	0.34	-1.29
Mean=	120.88	3.42	1.98
Std Dev=	70.76	2.00	0.36

Outliers

Kn=	2.134
Q-low =	**17 cfs**
Q-high =	**561 cfs**

Flow Frequency

From USGS Data

ALDER C NR POTTER VALLEY CA

Generalized Skew=	**-0.30**	A=	-0.13431
Station Skewness (log Q)=	-1.29	B=	0.60574
Station Mean (log Q)=	1.98	MSE (station skew) =	0.84021
Station Std Dev (log Q)=	0.36		
Weighted Skewness (G_W)=	**-0.56**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge per Mi^2 (cfs/mi^2)**
1.2	0.833	-0.97743	43	31.0
1.5	0.667	-0.35367	72	51.8
2.0	0.500	0.09298	104	74.9
5.0	0.200	0.85692	196	140.7
10	0.100	1.22452	265	190.5
25	0.040	1.54371	345	247.9
50	0.020	1.74272	406	292.2
100	0.010	1.90962	466	335.3

Values From K-Table for Linear interpolatior

Weighted Skewness =	-0.60	-0.50	-0.56
P	K	K	K
0.9	-1.32850	-1.32309	-1.32637
0.8	-0.79950	-0.80829	-0.80296
0.7	-0.44352	-0.45812	-0.44927
0.6	-0.15589	-0.17261	-0.16248
0.500	0.09945	0.08302	0.09298
0.429	0.27047	0.25558	0.26460
0.200	0.85718	0.85653	0.85692
0.100	1.20028	1.26180	1.22452
0.040	1.52830	1.56740	1.54371
0.020	1.72033	1.77716	1.74272
0.010	1.88029	1.95472	1.90962

Flood Frequency based on Annual-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	Drainage (sq mi)	Daily flow data count	Peak flow data count
11467850	SODA C TRIB NR BOONVILLE CA	39.02545	-123.2914	NAD83	1.53	1461	9

Flood Frequency based on Annual Maximum Series

Annual Maxima Series WY	Date of Peak	Discharge (cfs)
	12/22/1964	394
	3/25/1971	152
	1/4/1966	138
	1/20/1964	118
	1/13/1969	113
	1/16/1973	107
	2/13/1962	89
	1/21/1967	83
	1/29/1968	50

RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
1	10.00	394	11.16	2.60
2	5.00	152	4.30	2.18
3	3.33	138	3.91	2.14
4	2.50	118	3.34	2.07
5	2.00	113	3.20	2.05
6	1.67	107	3.03	2.03
7	1.43	89	2.52	1.95
8	1.25	83	2.35	1.92
9	1.11	50	1.42	1.70

Sample Size, n =	9		
Skewness =	2.48	2.48	1.00
Mean=	138.22	3.91	2.07
Std Dev=	100.55	2.85	0.24

Outliers

Kn= 2.134

Q-low = 36 cfs

Q-high = 388 cfs

Flow Frequency

From USGS Data

SODA C TRIB NR BOONVILLE CA

Generalized Skew=	**-0.30**	A=	-0.21876
Station Skewness (log Q)=	1.00	B=	0.67892
Station Mean (log Q)=	2.07	MSE (station skew) =	0.64910
Station Std Dev (log Q)=	0.24		
Weighted Skewness (G_W)=	**0.11**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge per mi^2 (cfs/mi^2)**
1.2	0.833	-0.98731	68	44.3
1.5	0.667	-0.44888	92	59.9
2.0	0.500	-0.01897	117	76.2
5.0	0.200	0.83555	188	122.7
10	0.100	1.29309	242	158.4
25	0.040	1.78927	320	209.0
50	0.020	2.11436	383	250.6
100	0.010	2.40986	452	295.6

Values From K-Table for Linear interpolatior

Weighted Skewness =	0.10	0.20	0.11
P	K	K	K
0.9	-1.27037	-1.25824	-1.26866
0.8	-0.84611	-0.84986	-0.84664
0.7	-0.53624	-0.54757	-0.53784
0.6	-0.26882	-0.28403	-0.27096
0.500	-0.01662	-0.03325	-0.01897
0.429	0.16111	0.14472	0.15880
0.200	0.83639	0.83044	0.83555
0.100	1.29178	1.30105	1.29309
0.040	1.78462	1.81756	1.78927
0.020	2.10697	2.15935	2.11436
0.010	2.39961	2.47226	2.40986

Flood Frequency based on Annuall-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	Drainage (sq mi)	Daily flow data count	Peak flow data count
11384400	SF STONY C NR STONYFORD CA	39.296	-122.753047	NAD83	2.52		11

Flood Frequency based on Annual Maximum Series

Annual Maxima Series WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
	1/16/1974	586	1	10.00	586	16.59	2.77
	1/23/1970	553	2	5.00	553	15.66	2.74
	1/13/1980	478	3	3.33	478	13.54	2.68
	1971-03	257	4	2.50	257	7.28	2.41
	1/16/1978	245	5	2.00	245	6.94	2.39
	2/12/1975	215	6	1.67	215	6.09	2.33
	1/16/1973	208	7	1.43	208	5.89	2.32
	1/22/1972	174	8	1.25	174	4.93	2.24
	3/27/1979	133	9	1.11	133	3.77	2.12

Sample Size, n =	9		
Skewness =	0.78	0.78	0.36
Mean=	316.56	8.96	2.44
Std Dev=	172.97	4.90	0.23

Outliers

Kn= 2.134

Q-low = **90 cfs**

Q-high = **866 cfs**

Flow Frequency

From USGS Data
SF STONY C NR STONYFORD CA

Generalized Skew=	**-0.30**	A=	-0.30099
Station Skewness (log Q)=	0.36	B=	0.84572
Station Mean (log Q)=	2.44	MSE (station skew) =	0.54665
Station Std Dev (log Q)=	0.23		
Weighted Skewness (G_{W})=	**-0.06**		

Log Pearson Type III Distribution

Return Period (years)	Exceedence Probability	Log-Pearson K	Predicicted Discharge (cfs)	Discharge per Mi^2 (cfs/mi^2)
1.2	0.833	-0.98821	165	65.4
1.5	0.667	-0.42541	222	88.2
2.0	0.500	0.01067	280	111.2
5.0	0.200	0.84450	436	173.1
10	0.100	1.27437	548	217.5
25	0.040	1.72829	698	276.9
50	0.020	2.01907	814	323.1
100	0.010	2.27899	935	371.0

Values From K-Table for Linear interpolatior

Weighted Skewness =	-0.10	0.00	-0.06
P	K	K	K
0.9	-1.29178	-1.28155	-1.28812
0.8	-0.83639	-0.84162	-0.83826
0.7	-0.51207	-0.52440	-0.51648
0.6	-0.23763	-0.25335	-0.24326
0.500	0.01662	0.00000	0.01067
0.429	0.19339	0.17733	0.18764
0.200	0.84611	0.84162	0.84450
0.100	1.27037	1.28155	1.27437
0.040	1.71580	1.75069	1.72829
0.020	1.99973	2.05375	2.01907
0.010	2.25258	2.32635	2.27899

Flood Frequency based on Annual-Duration Series

Site Number	Site Name	Dec. Lat.	Dec. Lon	Dec. lat/long datum	P	alt index H	Drainage (sq mi)	Daily flow data count	Peak flow data count
11448900	HIGHLAND C AB HIGHLAND C DAM CA	38.91962268	-122.92083	NAD83	37	1.9	11.9	5844	24

Flood Frequency based on Annual Maximum Series

Annual Maxima Series WY	Date of Peak	Discharge (cfs)	RANK	Recurrence Interval (years)	Discharge (cfs)	Discharge (cms)	log-discharge (cfs)
	1/16/1974	3140	1	24.00	3140	88.92	3.50
	12/22/1964	3080	2	12.00	3080	87.22	3.49
	1/23/1970	2980	3	8.00	2980	84.38	3.47
	1/14/1978	2710	4	6.00	2710	76.74	3.43
	1/16/1973	2390	5	4.80	2390	67.68	3.38
	10/12/1962	2320	6	4.00	2320	65.70	3.37
	2/24/1958	2280	7	3.43	2280	64.56	3.36
	2/21/1956	1860	8	3.00	1860	52.67	3.27
	3/21/1975	1810	9	2.67	1810	51.25	3.26
	12/1/1960	1800	10	2.40	1800	50.97	3.26
	1/20/1964	1520	11	2.18	1520	43.04	3.18
	2/16/1959	1440	12	2.00	1440	40.78	3.16
	12/15/1968	1430	13	1.85	1430	40.49	3.16
	2/24/1957	1370	14	1.71	1370	38.79	3.14
	1/29/1968	1320	15	1.60	1320	37.38	3.12
	2/8/1960	1290	16	1.50	1290	36.53	3.11
	1/4/1966	1290	17	1.41	1290	36.53	3.11
	12/3/1970	1230	18	1.33	1230	34.83	3.09
	12/2/1966	1210	19	1.26	1210	34.26	3.08
	12/22/1971	604	20	1.20	604	17.10	2.78
	11/15/1954	408	21	1.14	408	11.55	2.61
	4/7/1976	229	22	1.09	229	6.48	2.36
	1/2/1977	85	23	1.04	85	2.41	1.93

Sample Size, n =	23		
Skewness =	0.07	0.07	-1.86
Mean=	1643.30	46.53	3.11
Std Dev=	870.56	24.65	0.38
Outliers			
Kn=	2.134		
Q-low =	**204 cfs**		
Q-high =	**8,264 cfs**		

Flow Frequency

From USGS Data

HIGHLAND C AB HIGHLAND C DAM CA

Generalized Skew=	**-0.30**	A=	0.03912
Station Skewness (log Q)=	-1.86	B=	0.45543
Station Mean (log Q)=	3.11	MSE (station skew) =	0.74882
Station Std Dev (log Q)=	0.38		
Weighted Skewness (G_W)=	**-0.75**		

Log Pearson Type III Distribution

Return Period (years)	**Exceedence Probability**	**Log-Pearson K**	**Predicicted Discharge (cfs)**	**Discharge per mi^2 (cfs/mi^2)**
1.2	0.833	-0.96828	560	47.1
1.5	0.667	-0.32413	980	82.3
2.0	0.500	0.12379	1,445	121.4
5.0	0.200	0.85656	2,729	229.3
10	0.100	1.17471	3,596	302.2
25	0.040	1.46856	4,640	389.9
50	0.020	1.63498	5,360	450.5
100	0.010	1.76990	6,026	506.4

Values From K-Table for Linear interpolation

Weighted Skewness =	-0.80	-0.70	-0.75
P	K	K	K
0.9	-1.33640	-1.33294	-1.33465
0.8	-0.77986	-0.79022	-0.78510
0.7	-0.41309	-0.42851	-0.42089
0.6	-0.12199	-0.13901	-0.13060
0.500	0.13199	0.11578	0.12379
0.429	0.29961	0.28516	0.29230
0.200	0.85607	0.85703	0.85656
0.100	1.16574	1.18347	1.17471
0.040	1.44813	1.48852	1.46856
0.020	1.60604	1.66325	1.63498
0.010	1.73271	1.80621	1.76990

Appendix B
Culvert Hydraulic Calculations

HY-8 Culvert Analysis Report

Nokomis Road at Nissa-kah Creek

Table 1 - Culvert Summary Table: Existing Conditions

Total Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Headwater Description
330.00	674.39	7.085	0.000	5-S2n	3.897	4.556	4.051	0.000	13.578	HW/D=1 (headwater depth submerges soffit)
665.00	681.50	14.201	12.654	5-S2n	7.000	7.000	7.000	0.000	15.832	Headwater overtops road

Table 2 - Culvert Summary Table: Proposed Conditions

Total Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth (ft)	Outlet Control Depth (ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Headwater Description
330.00	674.39	7.085	7.085	5-S2n	3.897	4.556	4.051	4.300	13.578	HW/D=1 (headwater depth submerges soffit)
665.00	681.50	14.201	12.654	5-S2n	7.000	7.000	7.000	5.300	15.832	Headwater overtops road

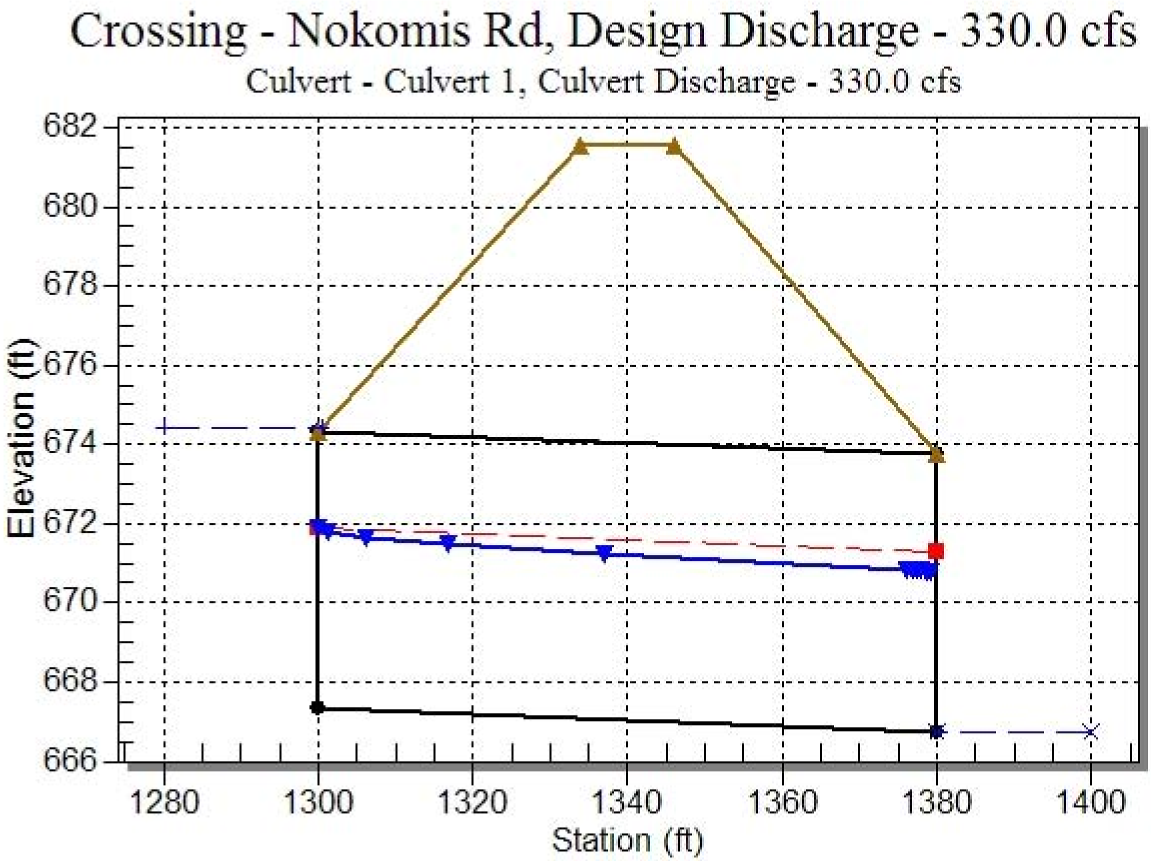
****

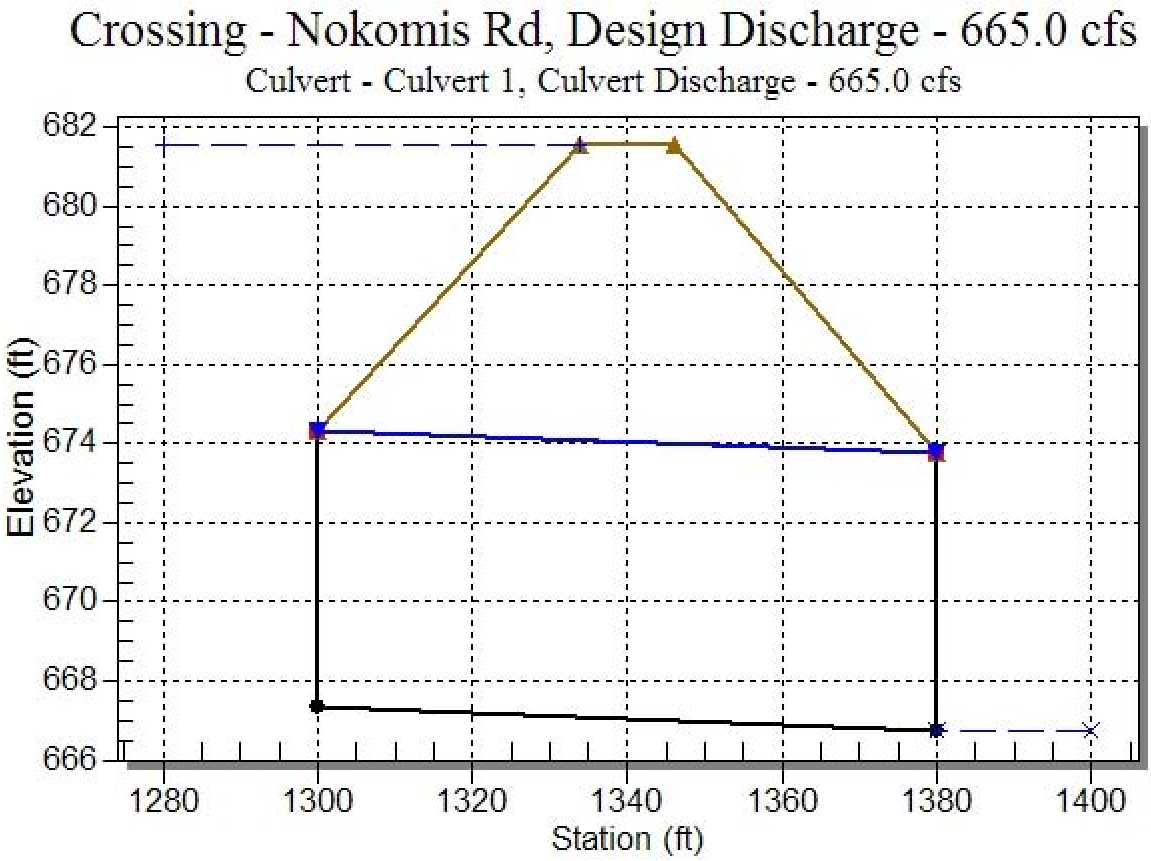
Inlet Elevation (invert): 667.30 ft, Outlet Elevation (invert): 666.70 ft

Culvert Length: 80.00 ft, Culvert Slope: 0.0075

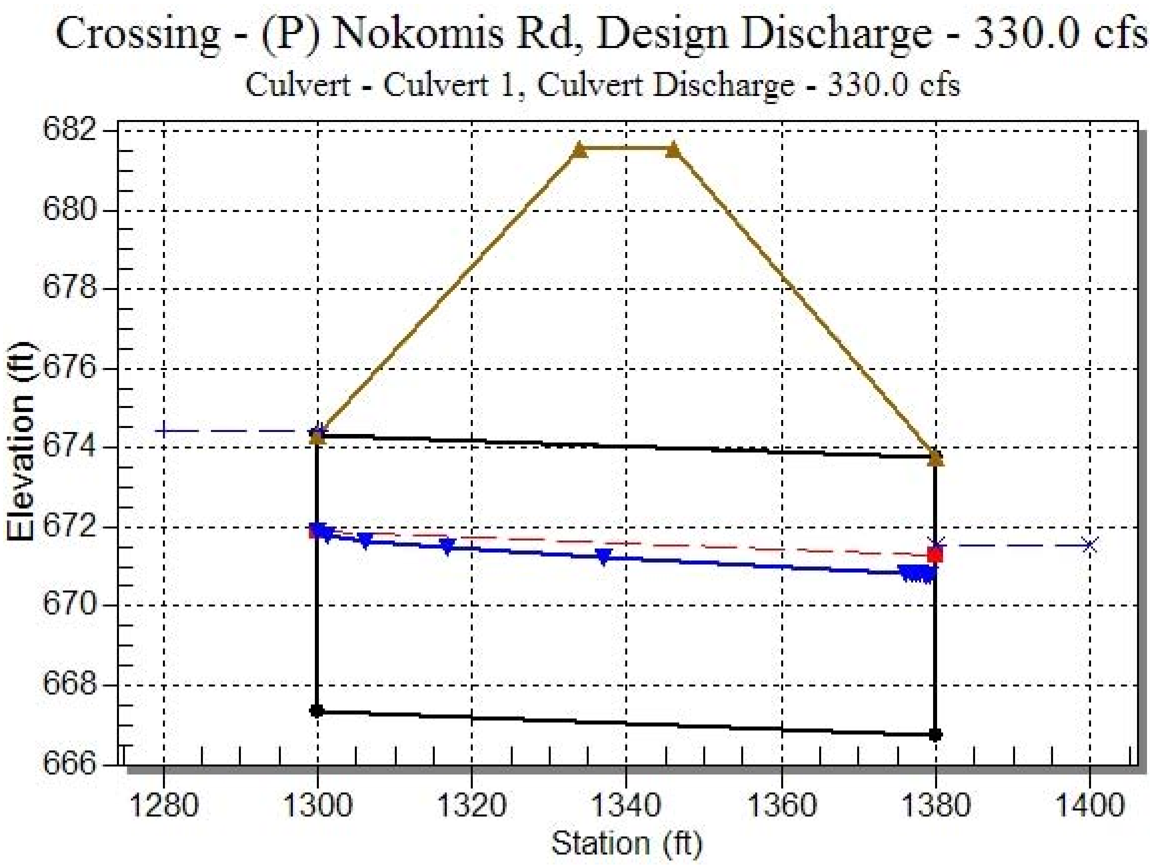
****

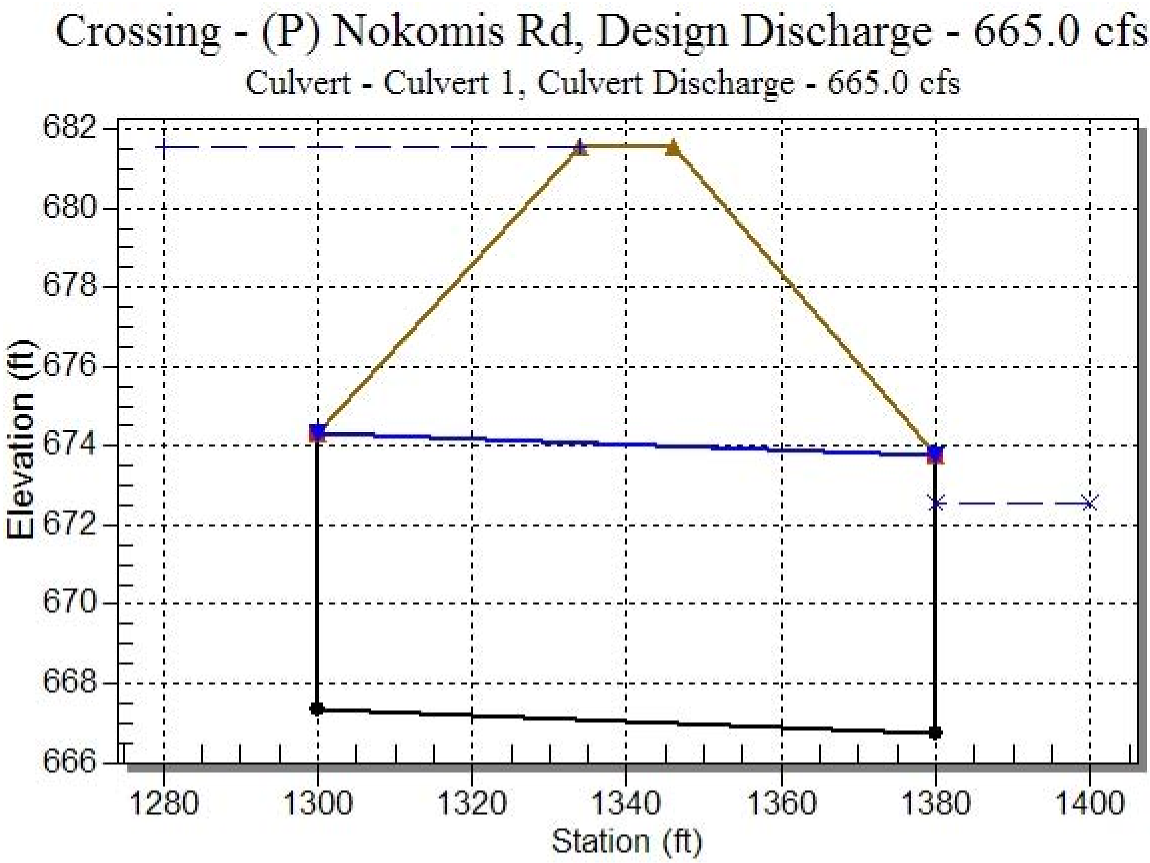
Water Surface Profile Plot for Culvert: Existing Conditions





Water Surface Profile Plot for Culvert: Proposed Conditions





Site Data - Culvert 1

Site Data Option: Culvert Invert Data

Inlet Station: 1300.00 ft

Inlet Elevation: 667.30 ft

Outlet Station: 1380.00 ft

Outlet Elevation: 666.70 ft

Number of Barrels: 1

Culvert Data Summary - Culvert 1

Barrel Shape: Concrete Box

Barrel Span: 6.00 ft

Barrel Rise: 7.00 ft

Barrel Material: Concrete

Barrel Manning's n: 0.0130

Inlet Type: Conventional

Inlet Edge Condition: Square Edge (30-75º flare) Wingwall

Inlet Depression: None

Tailwater Channel Data - Nokomis Rd

Existing Tailwater: Assumed to be below outlet apron at all flows set to constant elevation

Proposed Tailwater: Based on roughened channel rating table

Roadway Data for Crossing: Nokomis Rd

Roadway Profile Shape: Constant Roadway Elevation

Crest Length: 79.00 ft

Crest Elevation: 681.50 ft

Roadway Surface: Paved

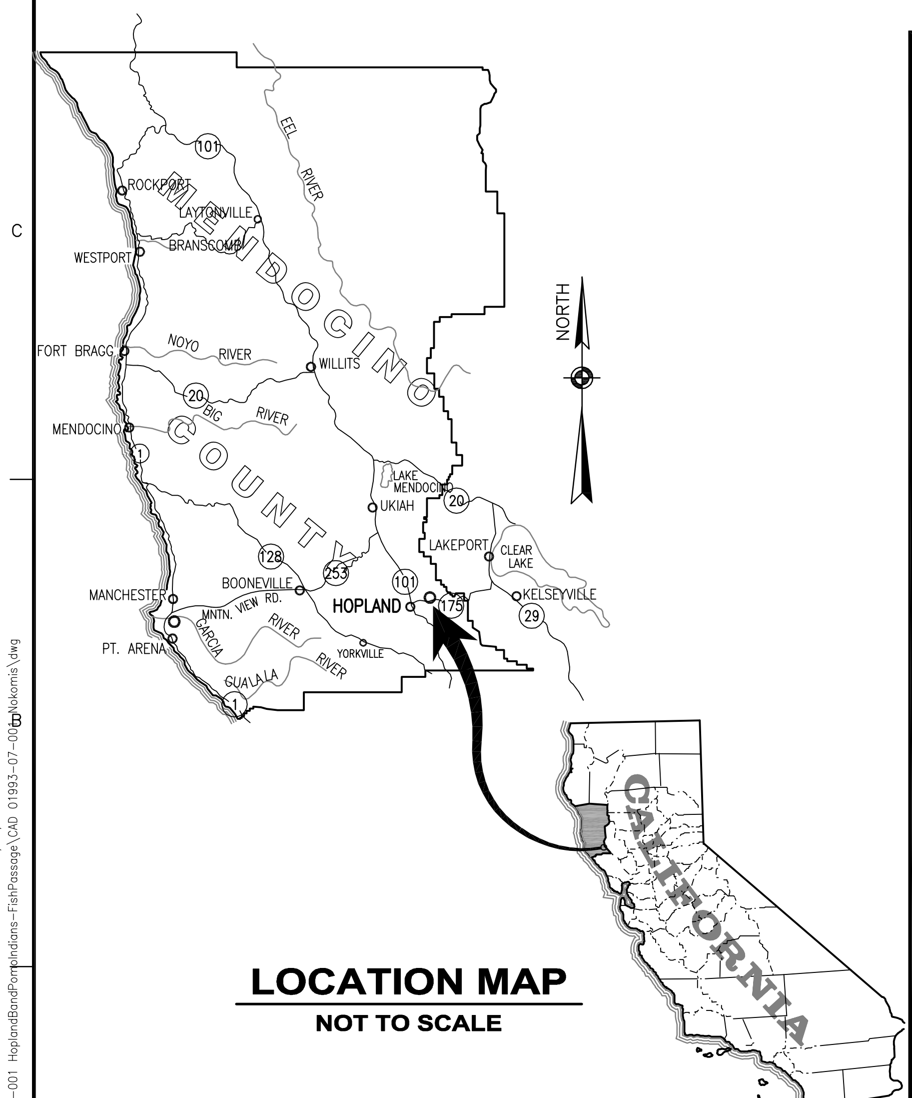
Roadway Top Width: 12.00 ft

Appendix C
90%Submittal Plans

HOPLAND BAND OF POMO INDIANS

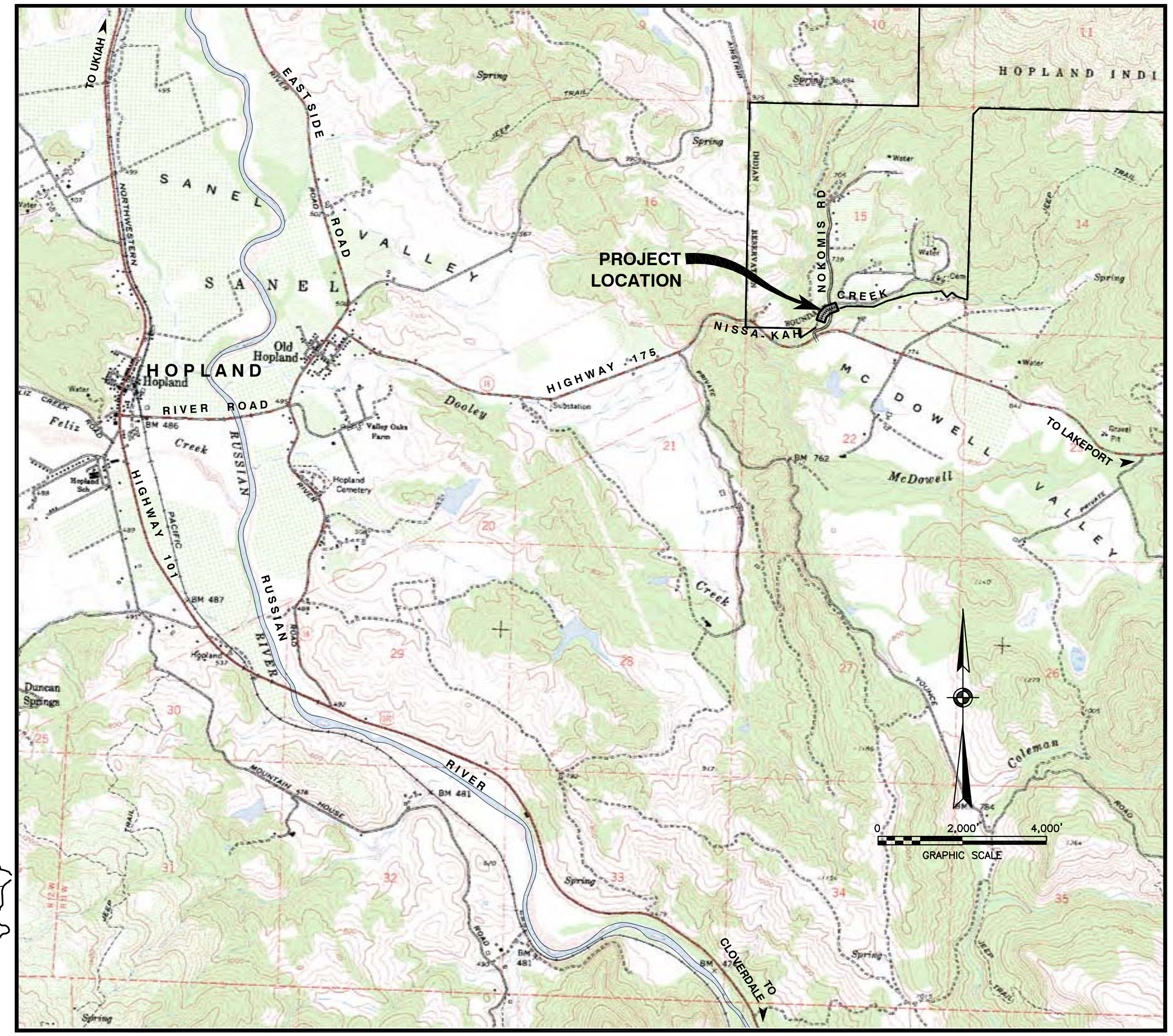
NISSA-KAH CREEK AT NOKOMIS RD FISH PASSAGE IMPROVEMENT PROJECT

NOVEMBER 2009



LOCATION MAP

NOT TO SCALE



SOURCE: USGS QUADRANGLE MAP

VICINITY MAP

SCALE: SEE SCALE BAR

SHEET INDEX

ENGINEER: WINZLER & KELLY

STEVEN ALLEN, PROJECT ENGINEER

APPROVAL ______ SIGNED ______ DATE

90% SUBMITTAL

NOT FOR CONSTRUCTION

NOVEMBER, 2009

SYM.	DESCRIPTION	DATE	APPROVED

REVISIONS

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT
Michael Love & Associates
PO Box 4477 Arcata, CA 95518 (707) 476-8938

DES TJ/AL DRN TJ/SJD SUPV SAA CHK SAA/MLA

SEE SCALE BAR

SEAL

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT NOKOMIS ROAD
FISH PASSAGE IMPROVEMENT
GENERAL

COVER SHEET

JOB NUMBER 01993-07-001

SHEET 1 OF 7

G-1

LEGEND:

GENERAL:

℄	CENTERLINE	@	AT
ø	DIAMETER	△	DELTA
±	APPROXIMATE		WATER SURFACE

A / G-2 C-1
SECTION OR DETAIL DESIGNATION (LETTER INDICATES SECTION, NO. INDICATES DETAIL)
SHEET WHERE SECTION OR DETAIL OCCURS
SHEET FROM WHICH SECTION OR DETAIL WAS TAKEN

TOPOGRAPHY

NEW	EXISTING	
—x—x—	—x—x—	FENCE
/// \\\	/// \\\	AC PAVEMENT
10 12	10 12	CONTOUR LINE
		FISH SCREEN
		TOP OF BANK
		TOE OF BANK
		DRAINAGE/CREEK/DITCH/SWALE
		BRUSH OR TREES
		TREE
		ROCK SLOPE PROTECTION
TBM		TEMPORARY BENCH MARK

UTILITIES

LINES		SYMBOLS	
W	WATER MAIN	PP	POWER POLE
SD	STORM DRAIN	T	TELEPHONE MANHOLE
SS	SANITARY SEWER	E	ELECTRICAL MANHOLE
E	ELECTRICAL (UNDERGROUND)		STREET LIGHT
E OHD	ELECTRICAL (OVERHEAD)	HYD	FIRE HYDRANT

ABBREVIATIONS:

AC	ASPHALT CONCRETE PAVING	(N)	NEW
APPROX	APPROXIMATE	OC	ON CENTER
CL	CENTER LINE	PP	POWER POLE
CMP	CORRUGATED METAL PIPE	RSP	ROCK SLOPE PROTECTION
CONC	CONCRETE	STA	STATION
E	ELECTRICAL	SD	STORM DRAIN
(E)	EXISTING	SS	SANITARY SEWER
EL	ELEVATION	SST	STAINLESS STEEL
E OHD	OVERHEAD ELECTRICAL LINES	T	TELEPHONE
ESM	ENGINEERED STREAMBED MATERIAL	TBD	TO BE DETERMINED
EW	ELECTRIC STREET WELL	TBM	TEMPORARY BENCH MARK
FT	FOOT or FEET	TYP	TYPICAL
HYD	FIRE HYDRANT	W/	WITH
INV	INVERT ELEVATION	W	WATER
IE	INVERT ELEVATION	XS	CROSS SECTION
MAX	MAXIMUM		
MH	MANHOLE		
MIN	MINIMUM		

NOTE: CONTACT ENGINEER FOR ABBREVIATIONS NOT LISTED.

GENERAL NOTES:

1. CONTRACTOR IS RESPONSIBLE FOR COMPLYING WITH ALL PROJECT PERMITS. OWNER IS RESPONSIBLE FOR OBTAINING AND PROVIDING COPIES OF ALL NECESSARY PROJECT PERMITS.
2. PRIOR TO COMMENCING ANY EXCAVATION OR DEMOLITION WORK, THE FISH SCREENS AND COFFER DAMS MUST BE INSTALLED AND FISH REMOVED FROM THE PROJECT AREA. CONTRACTOR SHALL COORDINATE WITH FISHERIES BIOLOGIST RESPONSIBLE FOR REMOVING FISH FOR SCHEDULING PLACEMENT OF FISH SCREENS, COFFER DAM AND DEWATERING PLAN. FISHERIES BIOLOGIST IS RESPONSIBLE FOR SITING THE BEST LOCATION FOR FISH SCREENS.
3. EXISTING VEGETATION SHALL BE PROTECTED AND LEFT UNDISTURBED AS MUCH AS PRACTICAL. EXISTING NATIVE PLANTS IN AREAS TO BE DISTURBED SHALL BE TRANSPLANTED PRIOR TO GROUND DISTURBANCE FOR REPLANTING AFTER FINAL GRADING HAS OCCURRED.
4. ALL UTILITIES SHOWN (IF ANY) WERE LOCATED FROM ABOVE GROUND VISUAL STRUCTURES. NO UTILITY RESEARCH WAS CONDUCTED FOR THIS SITE. NOTIFY UNDERGROUND SERVICE ALERT PRIOR TO ANY GRADING OR EXCAVATION WITHIN THE SITE AT 1-800-227-2600.
5. NATIVE TOPSOIL THAT IS EXCAVATED TO BE SEGREGATED AND STOCKPILED ON SITE FOR RE-USE AFTER ROUGH GRADING IS COMPLETE.
6. NATIVE STREAMBED MATERIAL THAT IS EXCAVATED SHALL BE SEGREGATED AND STOCKPILED ON SITE FOR RE-USE IN CHANNEL REGRADING.
7. UNSUITABLE EXCAVATED MATERIAL SHALL BE REMOVED FROM SITE AND DISPOSED OF IN A MANNER CONSISTENT WITH APPLICABLE REGULATIONS SUCH AS COUNTY GRADING ORDINANCES AND COASTAL GRADING PLANS. CONTRACTOR IS RESPONSIBLE FOR PROPER DISPOSAL OF UNSUITABLE MATERIALS TAKEN FROM SITE.
8. ANY PUMPS USED ON-SITE (DEWATERING ETC) SHALL BE PLACED ON ABSORBENT PADS. THE CONTRACTOR SHALL HAVE SPILL CONTAINMENT MATERIALS LOCATED AT THE SITE, WITH OPERATORS TRAINED IN SPILL CONTROL PROCEDURES.
9. ALL RSP ½ TON AND GREATER TO BE PLACED BY CALTRANS "METHOD A" PLACEMENT.
10. ALL LARGE WOODY DEBRIS FOUND IN PROJECT AREA SHALL BE STOCKPILED ON SITE FOR RE-USE AS DIRECTED BY THE ENGINEER.
11. WORK PHASING SHALL OCCUR AS FOLLOWS:
    A. MOBILIZATION,
    B. INSTALLATION OF FISH SCREENS, COFFER DAM CONSTRUCTION, DEWATERING AND FISH REMOVAL,
    C. CLEARING, GRUBBING, AND EXCAVATION WORK,
    D. IN-STREAM CHANNEL WORK (SEE SHEET C-4 FOR CHANNEL CONSTRUCTION SEQUENCING),
    E. PLACEMENT OF RSP, ENGINEERED STREAMBED MATERIAL, AND CULVERT SILL,
    F. FINAL GRADING, REVEGETATION, REMOVAL OF COFFERDAMS AND FISH SCREENS, DEMOBILIZATION.
12. CONTRACTOR SHALL SUBMIT IN WRITING TO THE ENGINEER THE PROPOSED CONSTRUCTION SCHEDULE AND THE PROPOSED APPROACH IN DEVELOPING AND PLACING THE SPECIFIED ENGINEERED STREAMBED MATERIAL PER SHEET C-4. THE ENGINEER MUST APPROVE PRIOR TO STARTING WORK.
13. THE CONTRACTOR SHALL IMMEDIATELY NOTIFY THE ENGINEER UPON DISCOVERING SIGNIFICANT DISCREPANCIES, ERRORS OR OMISSIONS IN THE PLANS. PRIOR TO PROCEEDING, THE OWNER SHALL HAVE THE PLANS REVISED TO CLARIFY IDENTIFIED DISCREPANCIES, ERRORS OR OMISSIONS.
14. PERFORM GRADING IN ACCORDANCE WITH THE LATEST EDITION OF APPENDIX CHAPTER 33 OF THE CALIFORNIA BUILDING CODE AND APPLICABLE MENDOCINO COUNTY REGULATIONS.
15. IN THE EVENT CULTURAL RESOURCES (I.E., HISTORICAL, ARCHAEOLOGICAL, AND PALEONTOLOGICAL RESOURCES, AND HUMAN REMAINS) ARE DISCOVERED DURING GRADING OR OTHER CONSTRUCTION ACTIVITIES, WORK SHALL BE HALTED WITHIN A 100 FOOT RADIUS OF THE FIND. A QUALIFIED ARCHEOLOGIST SHALL BE CONSULTED FOR AN ON-SITE EVALUATION. ADDITIONAL MITIGATION MAY BE REQUIRED BY THE COUNTY PER THE ARCHEOLOGIST'S RECOMMENDATIONS. IF HUMAN BURIALS OR HUMAN REMAINS ARE ENCOUNTERED, THE CONTRACTOR SHALL ALSO NOTIFY THE COUNTY CORONER.
16. SHOULD GRADING OPERATIONS ENCOUNTER HAZARDOUS MATERIALS, OR WHAT APPEAR TO BE HAZARDOUS MATERIALS, STOP WORK IN THE AFFECTED AREA IMMEDIATELY AND CONTACT 911 OR THE APPROPRIATE AGENCY FOR FURTHER INSTRUCTION.

EROSION & SEDIMENT CONTROL NOTES:

1. IT IS THE RESPONSIBILITY OF THE CONTRACTOR TO MINIMIZE EROSION AND PREVENT THE TRANSPORT OF SEDIMENT TO THE ADJACENT STREAM AND SENSITIVE AREAS.
2. AT A MINIMUM, THE CONTRACTOR SHALL EMPLOY THE FOLLOWING BEST MANAGEMENT PRACTICES (BMPS) AS DESCRIBED IN THE CURRENT CALTRANS STORM WATER QUALITY HANDBOOK AS NEEDED:

SS-2 PRESERVATION OF EXISTING VEGETATION	NS-5 CLEAR WATER DIVERSION
SS-6 REDWOOD MULCH	NS-9 VEHICLE EQUIPMENT AND FUELING
SS-10 OUTLET PROTECTION/VELOCITY DISSIPATION DEVICES	WM-1 MATERIALS DELIVERY AND STORAGE
SC-1 SILT FENCE	WM-2 MATERIAL USE
NS-2 DEWATERING OPERATIONS	WM-4 SPILL PREVENTION AND CONTROL
NS-3 PAVING AND GRINDING OPERATIONS	WM-9 SANITARY/SEPTIC WASTE MANAGEMENT

3. IT WILL BE THE RESPONSIBILITY OF THE CONTRACTOR TO FIX ANY DEFICIENCIES INDICATED BY THE OWNER OR THE OWNERS REPRESENTATIVE.
4. PRIOR TO FINAL ACCEPTANCE ALL AREAS OF THE SITE WILL BE VEGETATED OR PERMANENTLY STABILIZED AND ALL TEMPORARY SEDIMENT CONTROL MEASURES SHALL BE REMOVED.
5. ALL DISTURBED EARTH AREAS SHALL BE MULCHED AND SEEDED PER THE RE-VEGETATION PLAN.
6. PERFORM EROSION PREVENTION AND SEDIMENT CONTROL IN ACCORDANCE WITH THE LATEST EDITION OF APPENDIX CHAPTER 33 OF THE CALIFORNIA BUILDING CODE, APPLICABLE MENDOCINO COUNTY REGULATIONS, AND SECTION 20 OF THE CALTRANS STANDARD SPECIFICATIONS.
7. THE OWNER IS RESPONSIBLE FOR OBTAINING AND COMPLYING WITH THE NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM (NPDES) GENERAL PERMIT WASTE DISCHARGE REQUIREMENTS FOR DISCHARGES OF STORM WATER RUNOFF ASSOCIATED WITH CONSTRUCTION ACTIVITY. THIS PROJECT DISTURBANCE IS LESS THAN 1 ACRE, THEREFORE, THIS PERMIT MAY NOT BE REQUIRED FOR THIS PROJECT.
8. PRESERVATION OF EXISTING VEGETATION SHALL OCCUR TO THE MAXIMUM EXTENT PRACTICABLE.
9. DISCHARGES OF POTENTIAL POLLUTANTS FROM CONSTRUCTION SITES SHALL BE PREVENTED USING SOURCE CONTROLS TO THE MAXIMUM EXTENT PRACTICABLE. POTENTIAL POLLUTANTS INCLUDE BUT ARE NOT LIMITED TO: SEDIMENT, TRASH, NUTRIENTS, PATHOGENS, PETROLEUM HYDROCARBONS, METALS, CONCRETE, CEMENT, ASPHALT, LIME, PAINT, STAINS, GLUES, WOOD PRODUCTS, PESTICIDES, HERBICIDES, CHEMICALS, HAZARDOUS WASTE, SANITARY WASTE, VEHICLE OR EQUIPMENT WASH WATER AND CHLORINATED WATER.
10. WHENEVER IT IS NOT POSSIBLE TO UTILIZE EROSION PREVENTION MEASURES, EXPOSED SLOPES SHALL EMPLOY SEDIMENT CONTROL DEVICES, SUCH AS FIBER ROLLS AND SILT FENCES. FIBER ROLLS AND SILT FENCES SHALL BE TRENCHED AND KEYED INTO THE SOIL AND INSTALLED ON CONTOUR. SILT FENCES SHALL BE INSTALLED APPROXIMATELY 2 TO 5 FEET FROM TOE OF SLOPE.
11. SOIL AND MATERIAL STOCKPILES SHALL BE PROPERLY PROTECTED TO MINIMIZE SEDIMENT AND POLLUTANT TRANSPORT FROM THE CONSTRUCTION SITE.
12. SOLID WASTE, SUCH AS TRASH AND DEBRIS, SHALL BE PLACED IN DESIGNATED COLLECTION AREAS OR CONTAINERS. THE CONSTRUCTION SITE SHALL BE CLEARED OF SOLID WASTE DAILY, OR AS NECESSARY, AND REGULAR REMOVAL AND PROPER DISPOSAL SHALL BE ARRANGED.
13. PROPER APPLICATION, CLEANING AND STORAGE OF POTENTIALLY HAZARDOUS MATERIALS, SUCH AS PAINTS AND CHEMICALS, SHALL BE CONDUCTED TO PREVENT THE DISCHARGE OF POLLUTANTS.
14. WHEN UTILIZED, TEMPORARY RESTROOMS AND SANITARY FACILITIES SHALL BE LOCATED AND MAINTAINED TO PREVENT THE DISCHARGE OF POLLUTANTS.
15. APPROPRIATE VEHICLE STORAGE, FUELING, MAINTENANCE AND CLEANING AREAS SHALL BE DESIGNATED AND MAINTAINED TO PREVENT DISCHARGE OF POLLUTANTS.
16. ANY FUEL DRIVEN PUMPS USED ON-SITE (DEWATERING ETC) SHALL BE PLACED ON ABSORBENT PADS. THE CONTRACTOR SHALL HAVE SPILL CONTAINMENT MATERIALS LOCATED AT THE SITE, WITH OPERATORS TRAINED IN SPILL CONTROL PROCEDURES.

TOPOGRAPHIC SURVEY NOTES:

1. TOPOGRAPHIC DATA IS BASED ON A FIELD SURVEY CONDUCTED BY GUTIERREZ LAND SURVEYING ON FEBRUARY 26 & 27, 2008. CONTOUR INTERVAL = 1 FOOT.
2. BASIS OF ELEVATIONS: SCALED FROM QUAD MAPS. TEMPORARY BENCHMARK: TOP OF FIRE HYDRANT LOCATED IN EAST SIDE RANCHERIA ROAD NEAR NOKOMIS ROAD. ELEVATION = 683.91.
3. BASIS OF BEARINGS: ROTATION OF THIS MAP IS BASED ON COMPASS READINGS AT THE SITE.
4. ALL UTILITIES SHOWN WERE TAKEN FROM ABOVE GROUND VISUAL STRUCTURES. NO UTILITY RESEARCH WAS CONDUCTED. NOTIFY UNDERGROUND SERVICE ALERT PRIOR TO GRADING OR EXCAVATION WITHIN THE SITE AT 1-800-227-2600

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

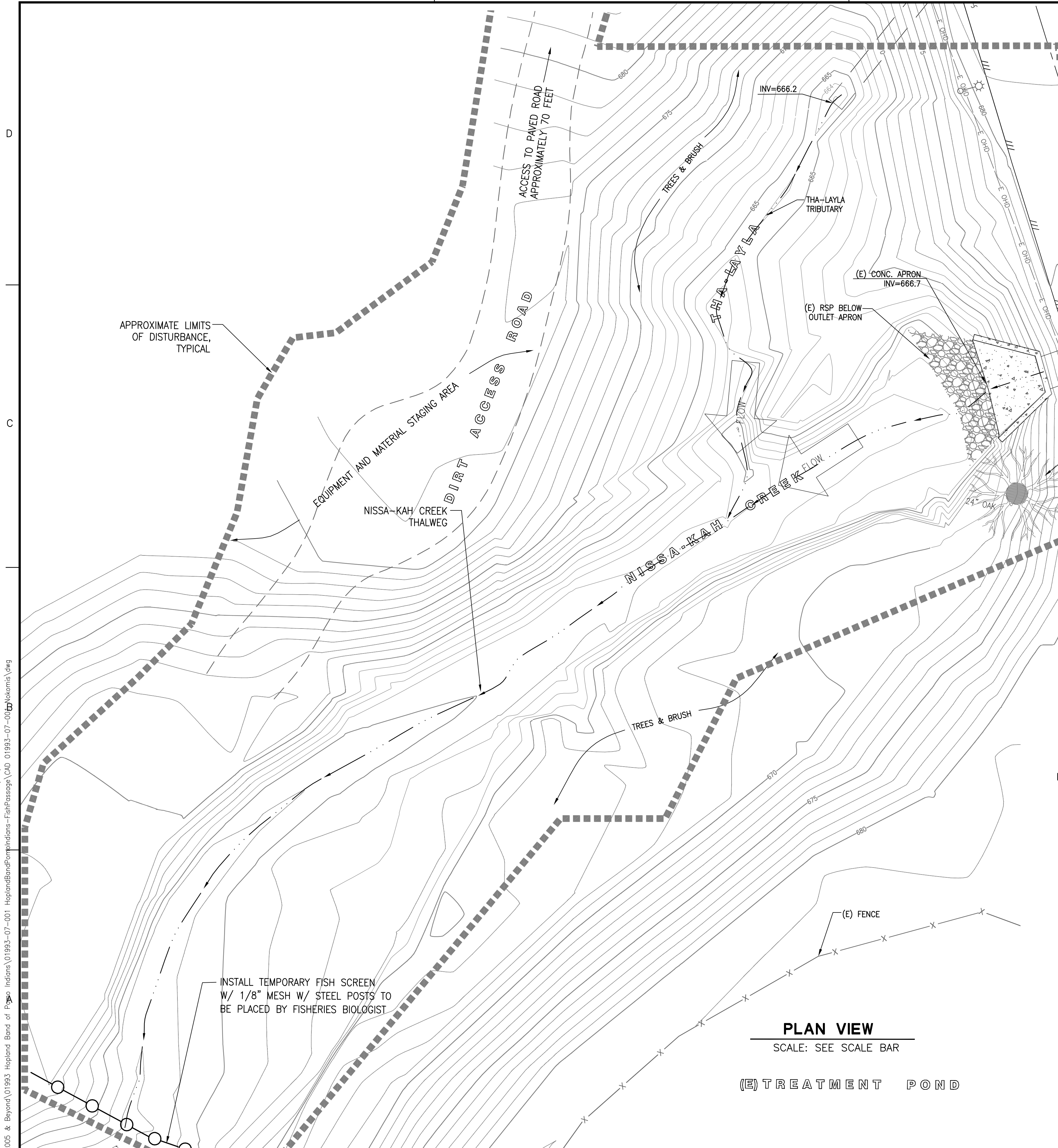
SUBCONSULTANT

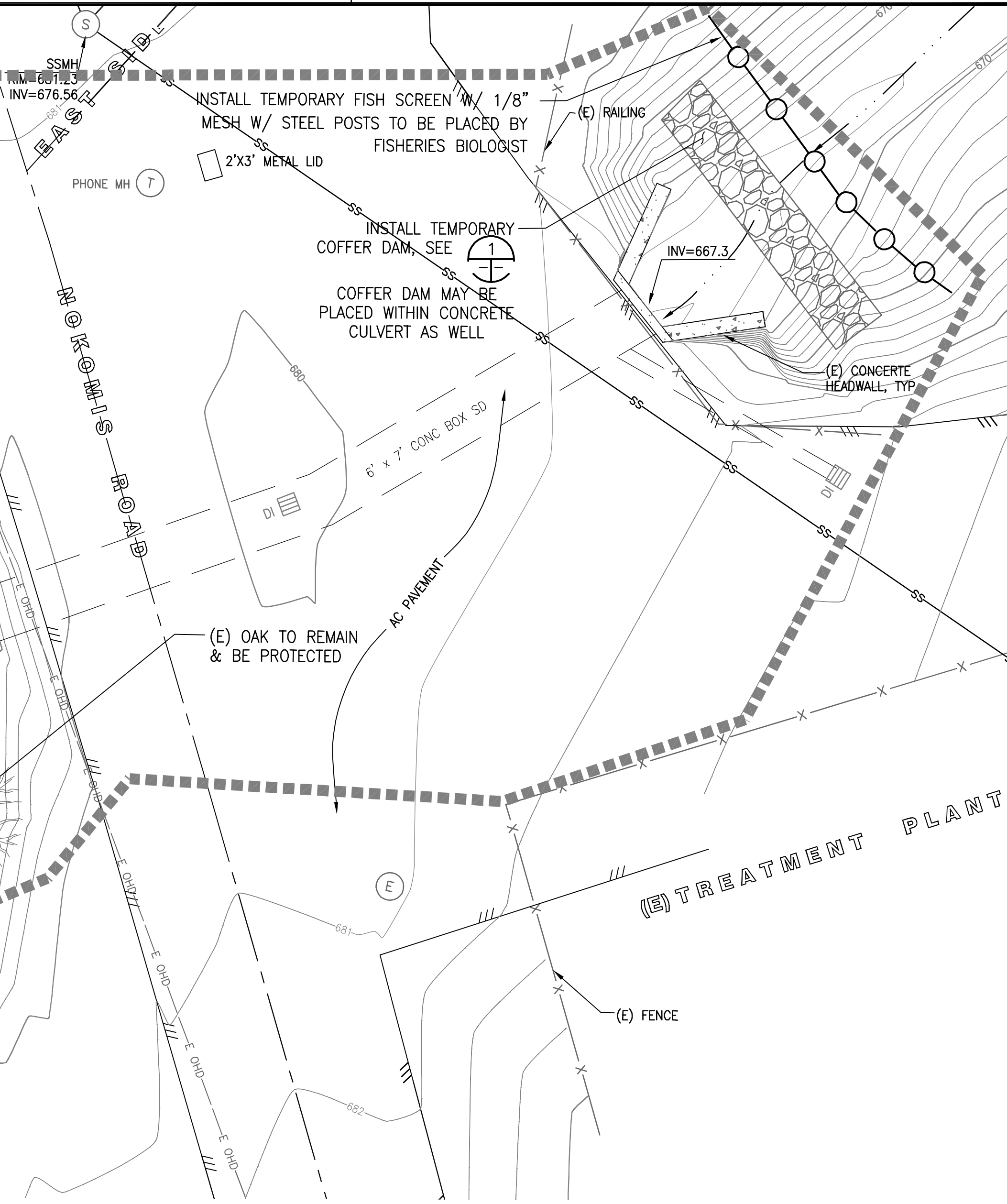
DES TJ/AL
DRN TJ/SJD
CHK SAA/MLA
SUPV SAA
SEE SCALE BAR

SEAL: REGISTERED PROFESSIONAL ENGINEER, STATE OF CALIFORNIA, CIVIL — DRAFT

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT NOKOMIS ROAD
FISH PASSAGE IMPROVEMENT
GENERAL
NOTES, SYMBOLS
AND ABBREVIATIONS

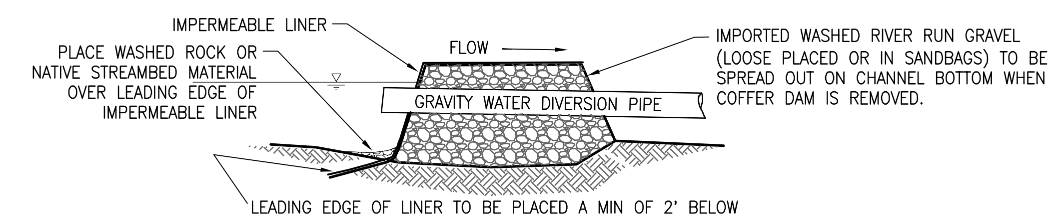
JOB NUMBER 01993-07-001





PLAN VIEW

SCALE: SEE SCALE BAR



NOTES:

1. OUTLET OF WATER DIVERSION PIPE TO BE PLACED ON A WASHED COBBLE ENERGY DISSIPATER AT LEAST 3'x3' IN SIZE PLACED IN CHANNEL UPSTREAM OF THE DOWNSTREAM FISH SCREEN.
2. USE GRAVITY LINE AS MUCH AS PRACTICAL.
3. WATER PUMPED FROM EXCAVATION SHALL BE PUMPED A MINIMUM OF 50 FEET FROM THE CHANNEL TO A STABLE AREA ABLE TO RECEIVE WATER AND ALLOW PERCOLATION INTO THE SOILS.

1 TEMPORARY COFFER DAM - SECTION DETAIL

SCALE: NOT TO SCALE

NOTE:
LOCATION OF EXISTING UTILITIES & STRUCTURES ARE FROM THE BEST INFORMATION AVAILABLE. EXACT LOCATION AND COMPLETENESS ARE NOT GUARANTEED. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICES ALERT (800) 227-2600 A MIN. OF 48 HOURS PRIOR TO ANY EXCAVATION AND POTHOLE FOR EXACT LOCATION.

90% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER, 2009

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET EUREKA, CA 95501-0417
PH (707) 443-8326 FAX (707) 444-8330
SUBCONSULTANT: Michael Love & Associates
PO Box 4477 Arcata, CA 95518 (707) 476-8938

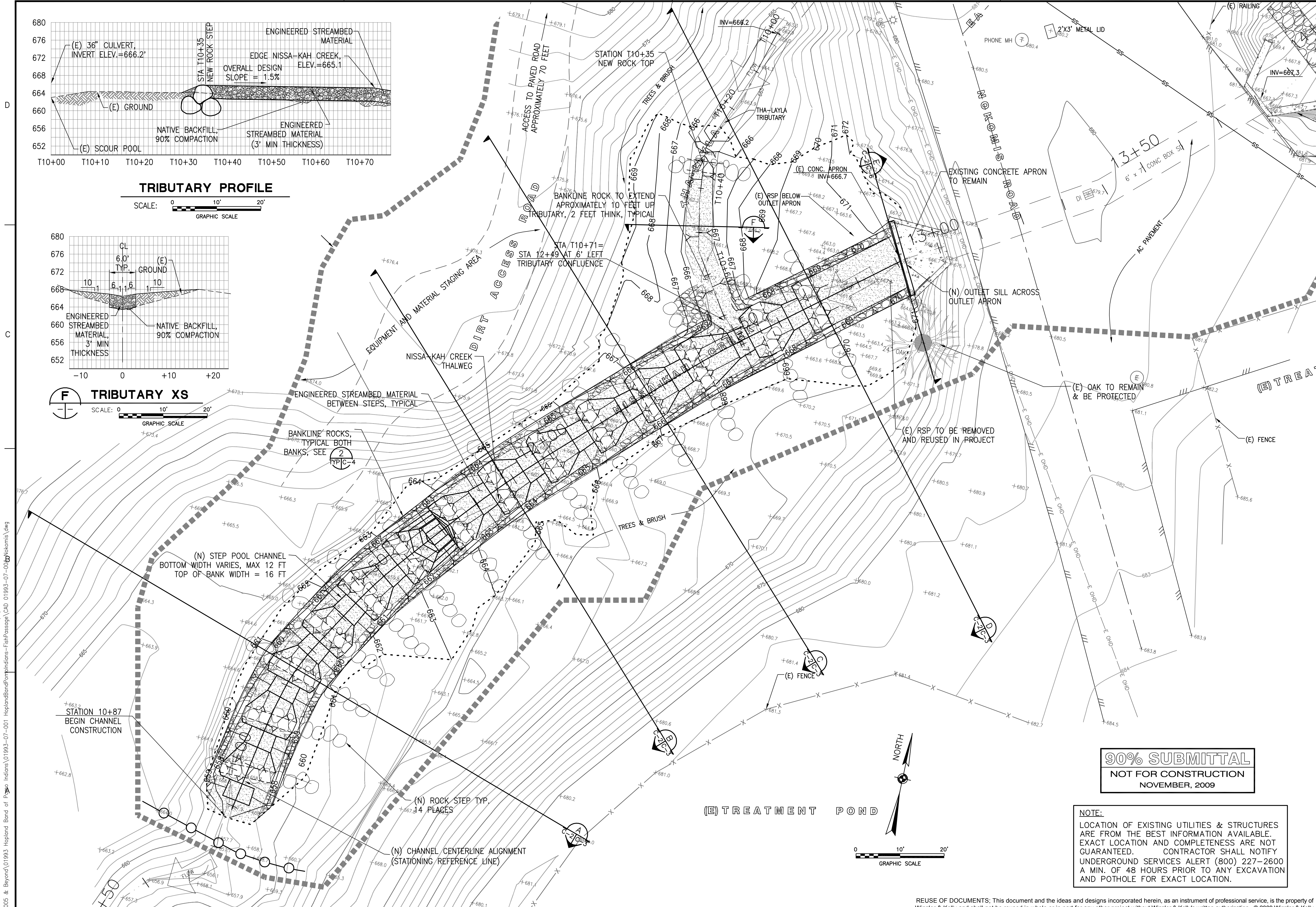
DES TJ/AL · DRN TJ/SJD · SUPV SAA · CHK SAA/MLA · SEE SCALE BAR

REGISTERED PROFESSIONAL ENGINEER · ALLEN · No. C 62021 · Exp. · CIVIL · STATE OF CALIFORNIA · DRAFT · SEAL

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT NOKOMIS ROAD
FISH PASSAGE IMPROVEMENT
CIVIL
EXISTING CONDITIONS & WATER MGMT PLAN

JOB NUMBER 01993-07-001
SHEET 3 OF 7
C-1

11/30/2009 2:04 PM
0199307001-Nokomis_03-C1
P:\2005 & Beyond\01993 Hopland Band of Pomo Indians\01993-07-001 HoplandBandPomoIndians-FishPassage\CAD 01993-07-00\Nokomis.dwg



90% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER, 2009

NOTE:
LOCATION OF EXISTING UTILITIES & STRUCTURES ARE FROM THE BEST INFORMATION AVAILABLE. EXACT LOCATION AND COMPLETENESS ARE NOT GUARANTEED. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICES ALERT (800) 227-2600 A MIN. OF 48 HOURS PRIOR TO ANY EXCAVATION AND POTHOLE FOR EXACT LOCATION.

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET EUREKA, CA 95501-0417
PH (707) 443-8326 FAX (707) 444-8330
SUBCONSULTANT
Michael Love & Associates
PO Box 4477 Arcata, CA 95518 (707) 476-8938

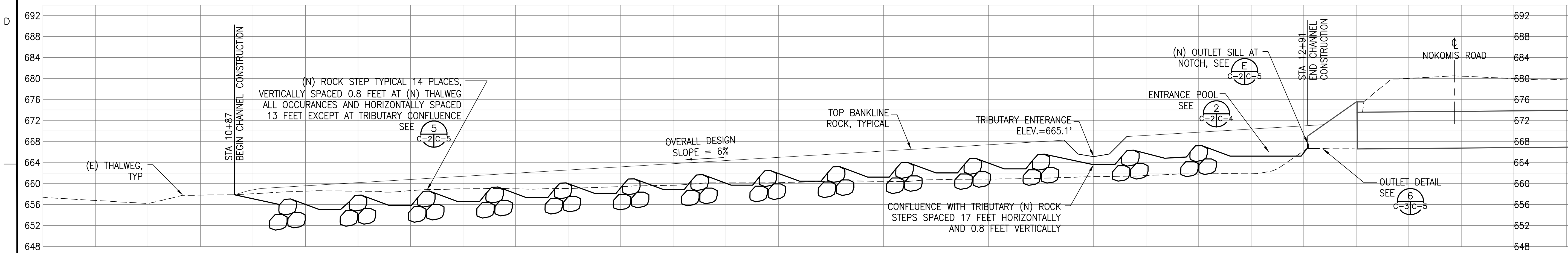
DES TJ/AL DRN TJ/SJD
SUPV SAA CHK SAA/MLA
SEE SCALE BAR

SEAL: REGISTERED PROFESSIONAL ENGINEER — DRAFT — STATE OF CALIFORNIA — CIVIL

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT NOKOMIS ROAD
FISH PASSAGE IMPROVEMENT
CIVIL
PLAN VIEW OF PROPOSED IMPROVEMENTS

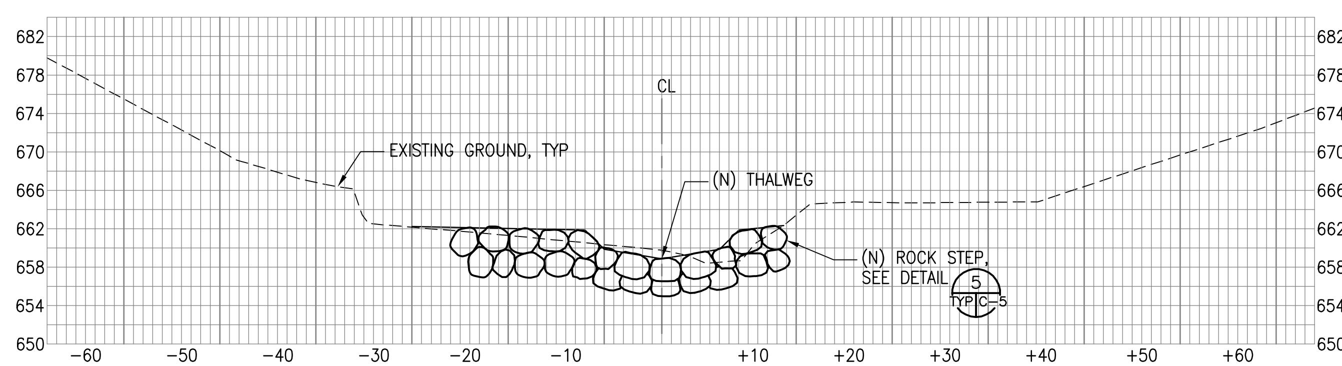
JOB NUMBER 01993-07-001
SHEET 4 OF 7
C-2

12/1/2009 4:37 PM
0199307001-Nokomis_04-C2
P:\2005 & Beyond\01993 Hopland Band of Pomo Indians\01993-07-001 HoplandBandPomoIndians-FishPassage\CAD 01993-07-00\Nokomis.dwg



CHANNEL PROFILE

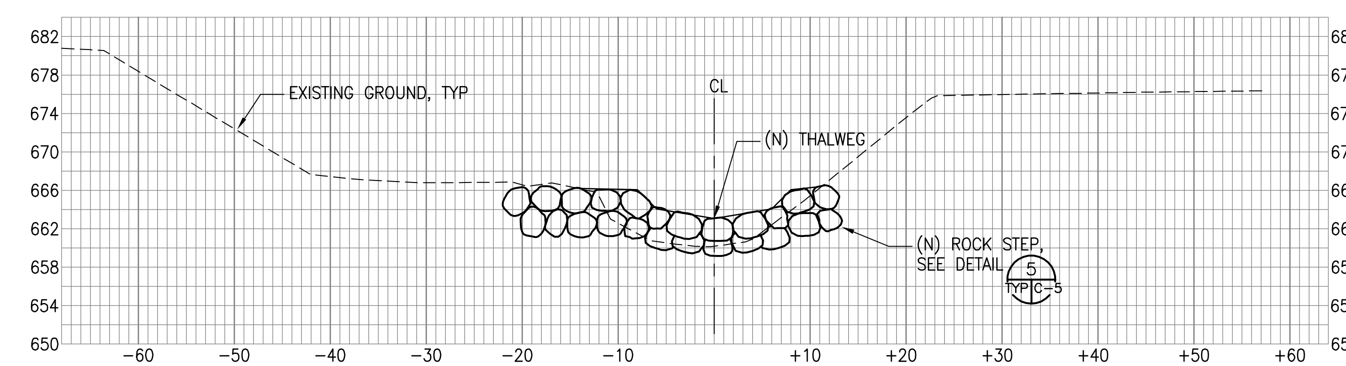
SCALE: 0 10' 20' GRAPHIC SCALE



A C-2 C-3 **CROSS SECTION - STA 11+25**

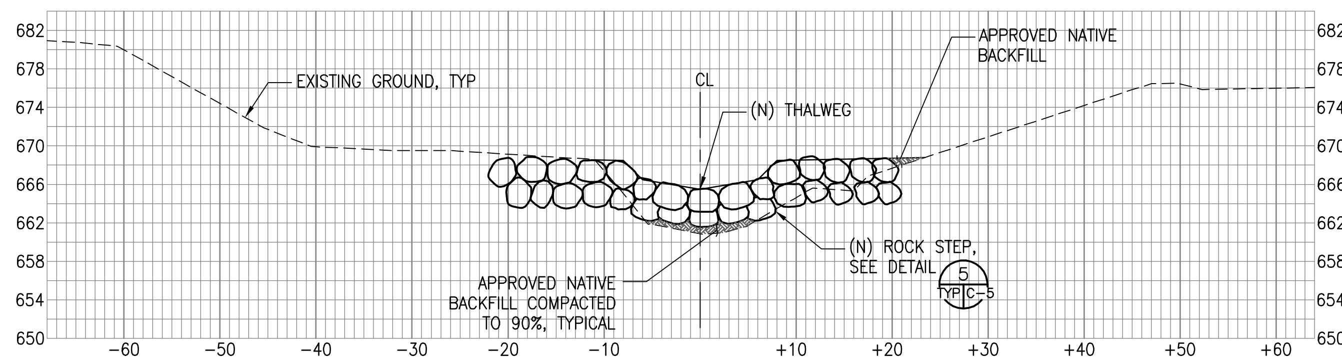
SCALE: SEE SCALE BAR

0 10' 20' GRAPHIC SCALE



B C-2 C-3 **CROSS SECTION - STA 11+90**

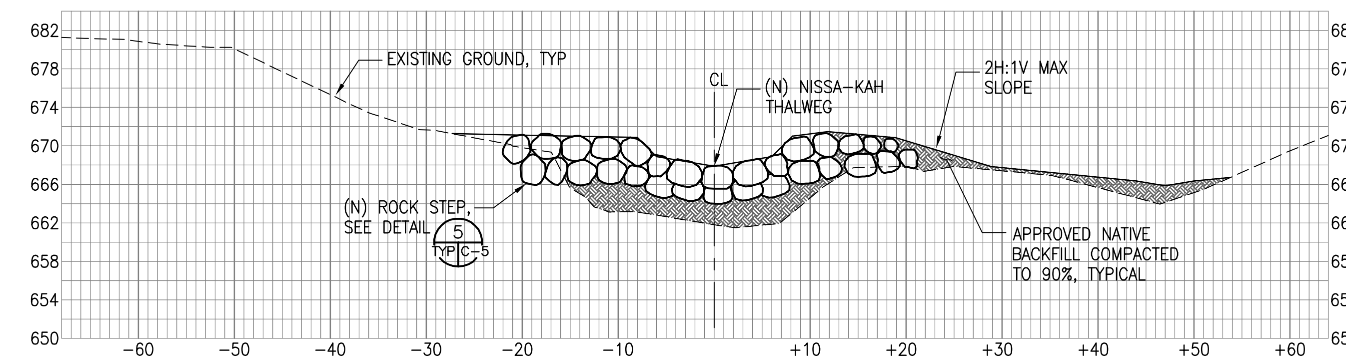
SCALE: SEE SCALE BAR



C C-2 C-3 **CROSS SECTION - STA 12+30**

SCALE: SEE SCALE BAR

0 10' 20' GRAPHIC SCALE



D C-2 C-3 **CROSS SECTION - STA 12+70**

SCALE: SEE SCALE BAR

90% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER, 2009

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

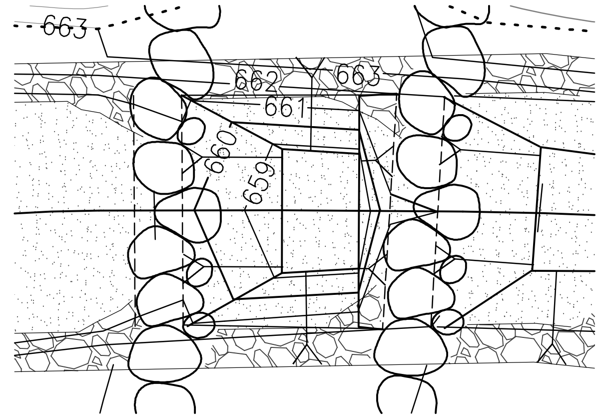
WINZLER & KELLY
633 THIRD STREET EUREKA, CA 95501-0417
PH (707) 443-8326 FAX (707) 444-8330
SUBCONSULTANT
Michael Love & Associates
PO Box 4477 Arcata, CA 95518 (707) 476-8938

DRN TJ/SJD CHK SAA/MLA
DES TJ/AL SUPV SAA
SEE SCALE BAR

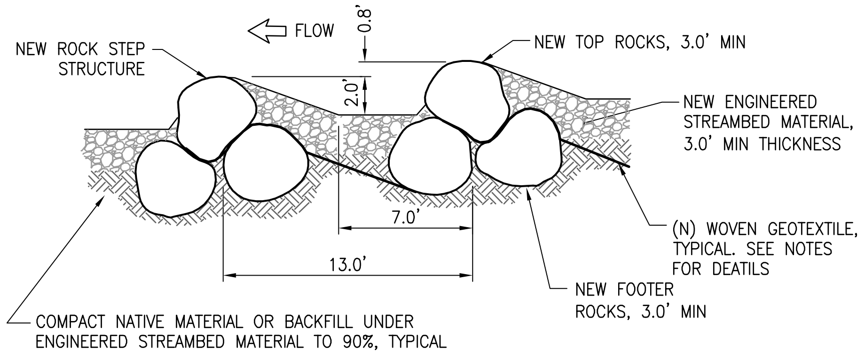
SEAL: REGISTERED PROFESSIONAL ENGINEER, SEAN A. ALLEN, No. 62021, Exp., CIVIL, STATE OF CALIFORNIA — DRAFT

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT NOKOMIS ROAD
FISH PASSAGE IMPROVEMENT
CIVIL
PROFILE & CROSS-SECTIONS

JOB NUMBER 01993-07-001
SHEET 5 OF 7
C-3

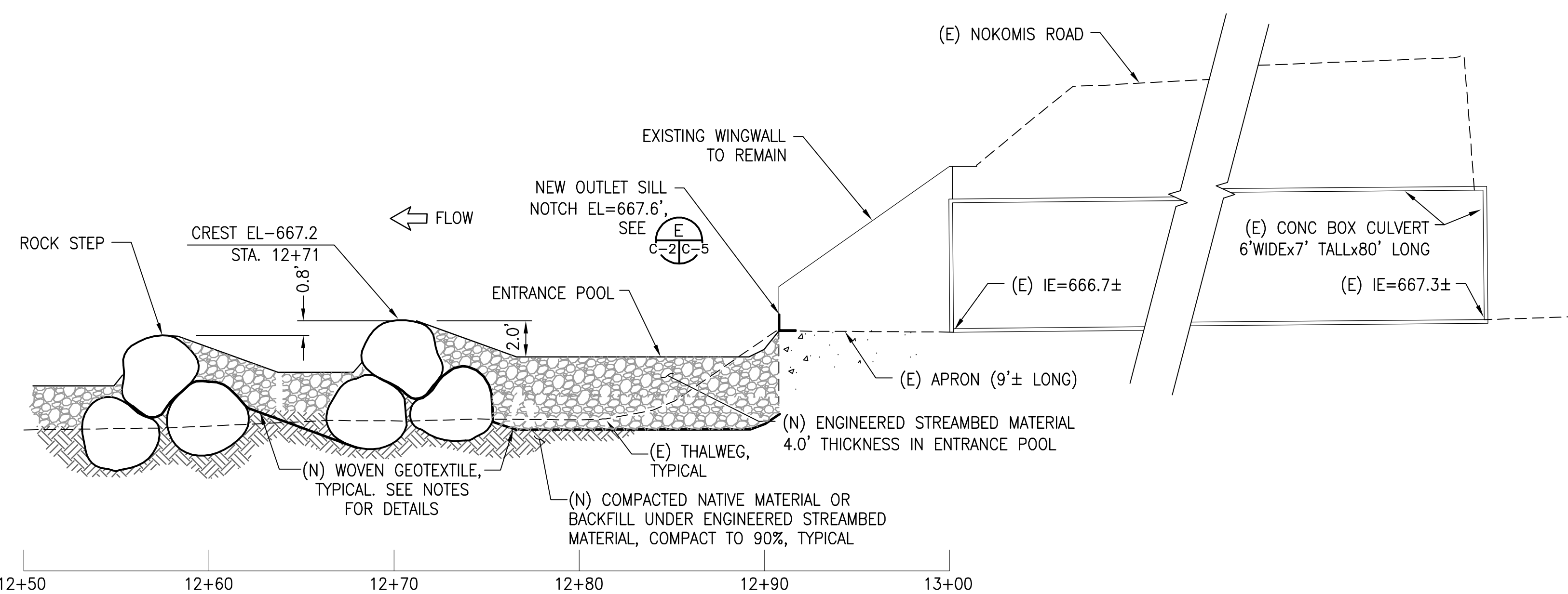


PLAN VIEW – STA 12+62± TO 12+75±



2 TYP C-4 **TYPICAL ROCK STEP STRUCTURE PROFILE**

SCALE: SEE SCALE BAR



3 TYP C-4 **DETAILED PROFILE AT CULVERT OUTLET**

SCALE: SEE SCALE BAR

90% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER, 2009

CHANNEL CONSTRUCTION NOTES:

GENERAL NOTES

1. ROCK PLACEMENT SHALL BE AT THE DESCRETION OF THE ENGINEER.
2. ALL ROCK DIMENSIONS ARE MEASURED ALONG THE INTERMEDIATE AXIS. THE LEAST DIMENSION (MINOR AXIS) OF AN INDIVIDUAL ROCK FRAGMENT SHALL NOT BE LESS THN ONE-THIRD THE GREATEST DIMENSION OF THE FRAGMENT. ROCK FOR ROCK BANDS SHALL HAVE A MINIMUM SPECIFIC GRAVITY OF 2.5 AND SHALL BE DURABLE AND OF SUITABLE QUALITY, SOUND AND DENSE, FREE FROM CRACKS, SEAMS AND OTHER DEFECTS THAT INCREASE DETERIORATION FROM WEATHERING.
3. ALL LARGE ROCK SHALL BE PLACED INDIVIDUALLY AND SECURED BY MACHINE TAMPING. FILLING VOIDS WITH SMALLER MATERIAL TO OBTAIN A COMPACT, LOW-PERMEABILITY MASS. ROCKS USED IN ROCK BANDS SHALL NOT BE CABLED TOGETHER.
4. CREST OF THE TOP ROCKS SHALL BE PLACED AT DESIGN ELEVATION, AND IN NO CASE EXCEED SIX INCHES ABOVE THE FINAL DESIGN ELEVATION OF THE CHANNEL.

ROCK STEPS

5. ROCK STEPS CONSIST OF TWO ROWS OF FOOTER ROCKS AND A SINGLE ROW OF TOP ROCKS.
6. ROCK STEPS ARE PERMANENT STRUCTURES INTENDED TO MAINTAIN THE ROUGHENED CHANNEL DESIGN GRADE, LEAD TO FORMATION OF SMALL STEPS AND POOLS, AND FACILITATE FISH PASSAGE.
7. PLACE BOTTOM OF FOOTER ROCKS IN TRENCH MINIMUM 4 FT BELOW FINISHED CHANNEL ELEVATION. INDIVIDUALLY PLACE FOOTER ROCKS SUCH THAT THEY EXERT PRESSURE ON EACH ADJACENT ROCK. ROCKS SELECTED FOR FOOTERS SHALL BE AMONG THE LARGEST, MOST ANGULAR ROCKS AVAILABLE.
8. SELECT TOP ROCKS, WHICH FIT SECURELY ON TOP OF AND BETWEEN THE TWO ROWS OF FOOTER ROCKS. TOP ROCKS SHOULD HAVE MINIMUM FOUR CONTACT POINTS AND BE SECURELY SUPPORTED BY FOOTER ROCKS.
9. CREST OF ROCK STEPS WITHIN THE ACTIVE CHANNEL SHALL SLOPE UPWARDS AT A 6H:1V SIDE SLOPE FROM THE CENTERLINE ELEVATION.
10. TOP ROCKS SHALL NOT PROTRUDE GREATER THAN 6 INCHES ABOVE THE FINISHED STREAMBED ELEVATION.

BANKLINE ROCKS

11. BANKLINE ROCKS DEFINE THE EDGES OF THE CHANNEL BANKLINES AND ARE TO BE RIGID AND RESISTANT TO EROSION. FACES SHOULD BE UNEVEN, PROTRUDE INTO THE CHANNEL AND BE ROUGH IN APPEARANCE.
12. BANKLINES SHALL CONSIST OF 1/4 TON CALTRANS CLASS ROCK. FACING CLASS ROCK SHALL BE USED TO FILL THE LARGER VOIDS. WORK SMALLER ROCKS AND FINES IN TO FILL THE REMAINING VOIDS. BOTTOM OF BANKLINES SET 3 FT BELOW FINISHED CHANNEL ELEVATION. BANKLINES SHALL HAVE A MINIMUM THICKNESS OF 2.5 FEET.

ENGINEERED STREAMBED MATERIAL

13. PLACE ENGINEERED STREAMBED MATERIAL WITHIN THE ROUGHENED CHANNEL REACH, BETWEEN STATION 10+87 AND STA. 12+91.
14. THE NEW CHANNEL IS 194 FT LONG WITH AN OVERAL SLOPE OF 6%. THE ROCK STEP STRUCTURES ARE SPACED 13 FT WITH THE EXCEPTION OF THE ROCK STEPS FORMING THE POOL AT THE TRIBUTARY CONFLUENCE, WHICH ARE SEPERATED BY 17 FT. EACH ROCK BAND HAS A 0.8 FT DROP. THE CHANNEL IS DESIGNED TO MAINTAIN THE SHAPE AND FUNCTION WITH ONLY MINOR ADJUSTMENT DURING HIGH FLOWS.
15. ENGINEERED STREAMBED MATERIAL SHALL BE A WELL-GRADED MIX (SEE TABLE ON THIS SHEET). ALL MATERIAL LARGER THAN 8-INCH DIAMETER SHALL BE ANGULAR. CONTRACTOR SHALL MIX THE MATERIAL ON-SITE AND MUST BE APPROVED BY THE ENGINEER. NATIVE STREAMBED MATERIAL MAY BE USED, IF FINAL MIXTURE CONFORMS TO SPECIFICATIONS. ROCK SIZE AND GRADATION SHALL CONFORM TO THE GRADATIONS SHOWN ON THIS SHEET.
16. PRIOR TO DEVELOPING ENGINEERED STREAMBED MATERIAL MIX, THE CONTRACTOR SHALL SUBMIT IN WRITING TO THE ENGINEER THE PROPOSED APPROACH FOR ACHIEVING THE SPECIFIED GRADATION. THE ENGINEER MUST APPROVE CONTRACTOR'S PROPOSED APPROACH PRIOR TO DEVELOPING ENGINEERED STREAMBED MATERIAL GRADATION.
17. ENGINEERED STREAMBED MATERIAL SHALL HAVE A MINIMUM THICKNESS OF 3 FEET AND BE TAMPED INTO PLACE. THE CHANNEL BED SHALL BE SLOPED TO THE CENTER AS SHOWN IN THE PLANS. ETHE ENTRANCE POOL ENGINEERED STREAMBED MATERIAL SHALL BE 4 FOOT THICKNESS.
18. ROCK THAT ARE 12 INCHES AND LARGER IN SIZE WITHIN THE ESM MIX, SHALL BE VISIBLY IN CONTACT WITH ONE ANOTHER.

COMPACTING NEW CHANNEL STREAMBED AND BANKLINES

19. TAMPING COMBINED WITH REPEATED JETTING OR FLOODING OF STREAMBED AND BANKLINES THROUGHOUT PROJECT REACH SHALL BE DONE TO COMPACT STREAMBED, FILL VOIDS, AND REDUCE POROSITY TO MINIMIZE SUBSURFACE FLOW.
20. FILLER MATERIAL SHALL CONSIST OF UNWASHED RIVER-RUN GRAVEL. 100% OF FILLER MATERIAL SHALL BE SMALLER THAN 2 INCHES AND NO LESS THAN 30% SHALL PASS THROUGH SIEVE NO. 10.
21. PLACE FILLER MATERIAL OVER STREAMBED AND BANKLINES MINIMUM 1 INCH THICK. TAMP FILLER MATERIAL INTO STREAMBED AND BANKLINES TO FILL VOIDS, FOLLOWED BY JETTING OR FLOODING OF STREAMBED AND BANKLINES. CONTINUE UNTIL VOIDS VISUALLY APPEAR FILLED AND WATER REMAINS FLOWING ON THE SURFACE ACROSS THE ENTIRE LENGTH OF THE PROJECT REACH.
22. NO WATER USED DURING THE JETTING OR FLOODING PROCESS SHALL BE ALLOWED TO DISCHARGE INTO THE STREAM, BUT SHALL BE REUSED OR PUMPED OFFSITE AT LEAST THE MINIMUM DISTANCE SET BY THE DEPARTMENT OF WATER RESOURCES. FILLER MATERIAL WASHED DOWNSTREAM AND DEPOSITED AT THE END OF PROJECT REACH SHALL BE REMOVED AND REUSED OR DISPOSED OF OFF-SITE.

GEOTEXTILE INSTALATION

23. THE GEOTEXTILE SHALL BE AMOCO WOVEN GEOTEXTILE TYPE 2000 OR APPROVED EQUIVALENT.
24. THE GEOTEXTILE SHALL BE INSTALLED BETWEEN EACH PAIR OF ROCK STEPS AND WITHIN THE ENTRANCE POOL SEPERATELY. THE GEOTEXTILE SHALL BE "PINCHED" BETWEEN THE FOOTER ROCKS AND THE TOP ROCKS OF THE DOWNSTREAM ROCK STEP FOR EACH INSTALLATION. THE GEOTEXTILE SHALL BE INSTALLED BENEATH THE ENGINEERED STREAMBED MATERIAL AND EXTEND TO THE UPSTREAM FOOTER ROCK FOR EACH INSTALLATION. THE GEOTEXTILE SHALL EXTEND UPSTREAM TO THE EXISTING CULVERT IN THE ENTRANCE POOL.

FOLLOW MANUFACTURES INSTALLATION INSTRUCTIONS TO MEET ABOVE REQUIREMENTS.

CHANNEL CONSTRUCTION SEQUENCING

25. COMPLETE ALL EXCAVATION AND PREPARATION OF SUB GRADE FOR ROUGHENED CHANNEL AND TRENCHES FOR ROCK BANDS.
26. CONSTRUCT ROCK STEPS AND INSTALL GEOTEXTILE.
27. CONSTRUCT BANKLINES ALONG ENTIRE PROJECT REACH.
28. PLACE ENGINEERED STREAMBED MATERIAL BETWEEN BANKLINE ROCKS IN ROUGHENED CHANNEL REACH, AS SHOWN IN THE PLANS. WORK FROM DOWNSTREAM TO UPSTREAM PLACING THE ENGINEERED STREAMBED MATERIAL.
29. PLACE FILLER MATERIAL ON CHANNEL BED AND BANKLINES THROUGHOUT PROJECT REACH AND JET OR FLOOD TO FILL VOIDS AND REDUCE SUBSURFACE FLOW.

NOTE:
ENGINEERED STREAMBED MATERIAL GRADATION

PERCENT OF MIX	RANGE OF SIZE (INCHES)
16	20 – 26
16	12 – 20
16	6 – 12
18	4 – 6
24	#8 SIEVE (2.38mm) – 4
8	<#10 SIEVE (2mm)

NOTE:
LOCATION OF EXISTING UTILITIES & STRUCTURES ARE FROM THE BEST INFORMATION AVAILABLE. EXACT LOCATION AND COMPLETENESS ARE NOT GUARANTEED. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICES ALERT (800) 227-2600 A MIN. OF 48 HOURS PRIOR TO ANY EXCAVATION AND POTHOLE FOR EXACT LOCATION.

SYM. DESCRIPTION DATE APPROVED
REVISIONS

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330
SUBCONSULTANT
Michael Love & Associates
PO Box 4477 Arcata, CA 95518 (707) 476-8938

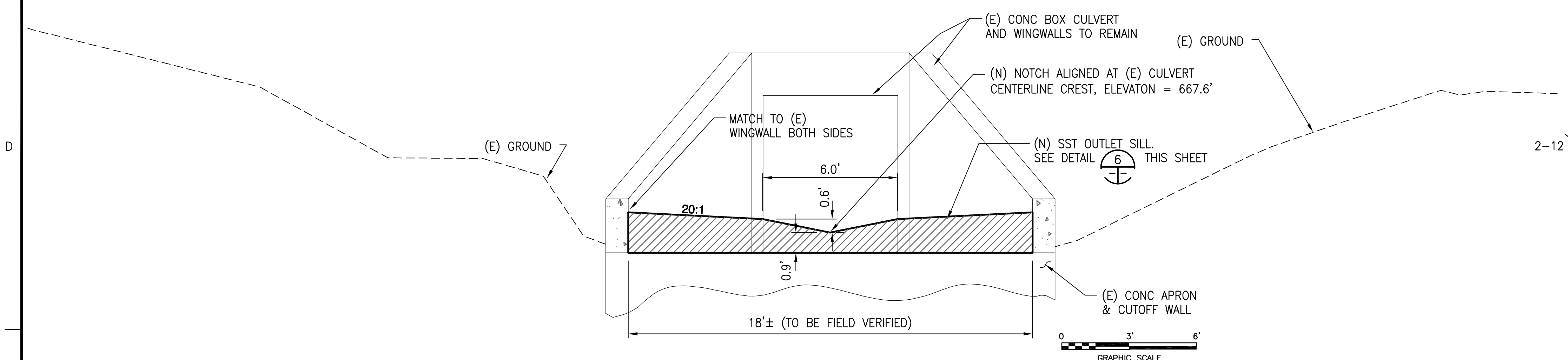
DES. TJ/AL DRN. TJ/SJD SUPV SAA CHK SAA/MLA
SEE SCALE BAR

DRAFT

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT NOKOMIS ROAD
FISH PASSAGE IMPROVEMENT
CIVIL
TYPICAL PROFILES &
CHANNEL CONSTRUCTION NOTES

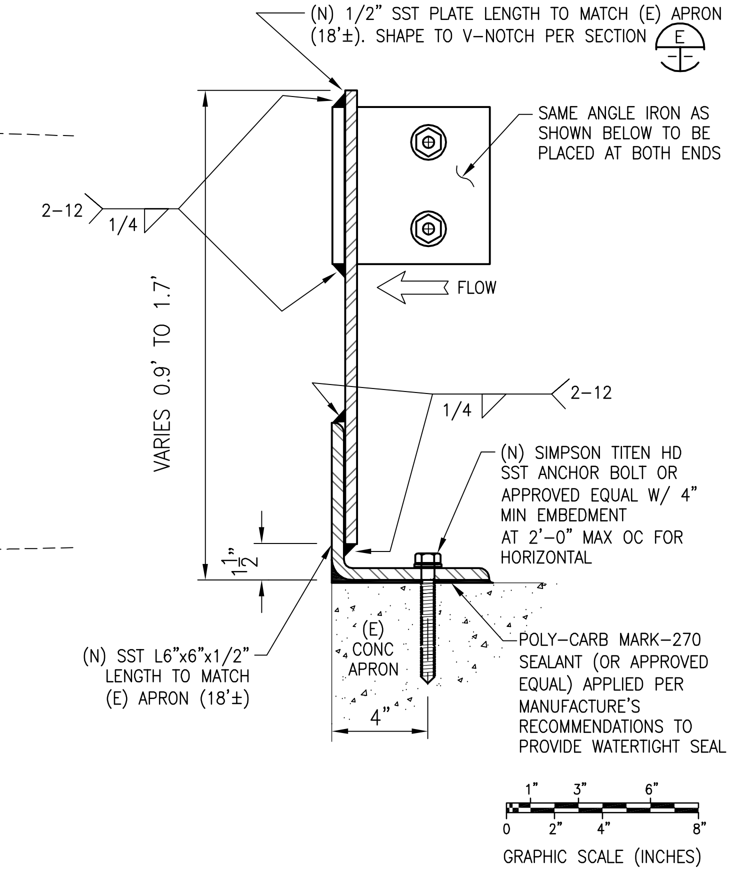
JOB NUMBER 01993-07-001
SHEET 6 OF 7
C-4

11/30/2009 2:07 PM
019930701-Nokomis_06-C4
P:\2005 & Beyond\01993 Hopland Band of Pomo Indians\01993-07-001 HoplandBandPomoIndians-FishPassage\CAD 01993-07-001Nokomis\dwg



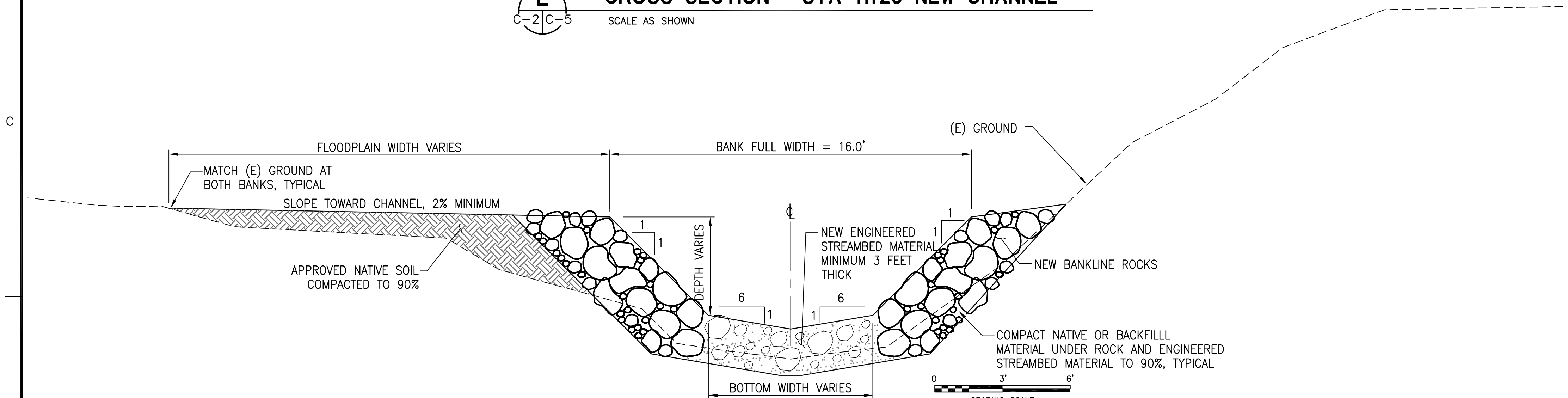
E C-2 C-5 **CROSS SECTION - STA 11+20 NEW CHANNEL**

SCALE AS SHOWN



6 TYP C-5 **OUTLET SILL DETAIL**

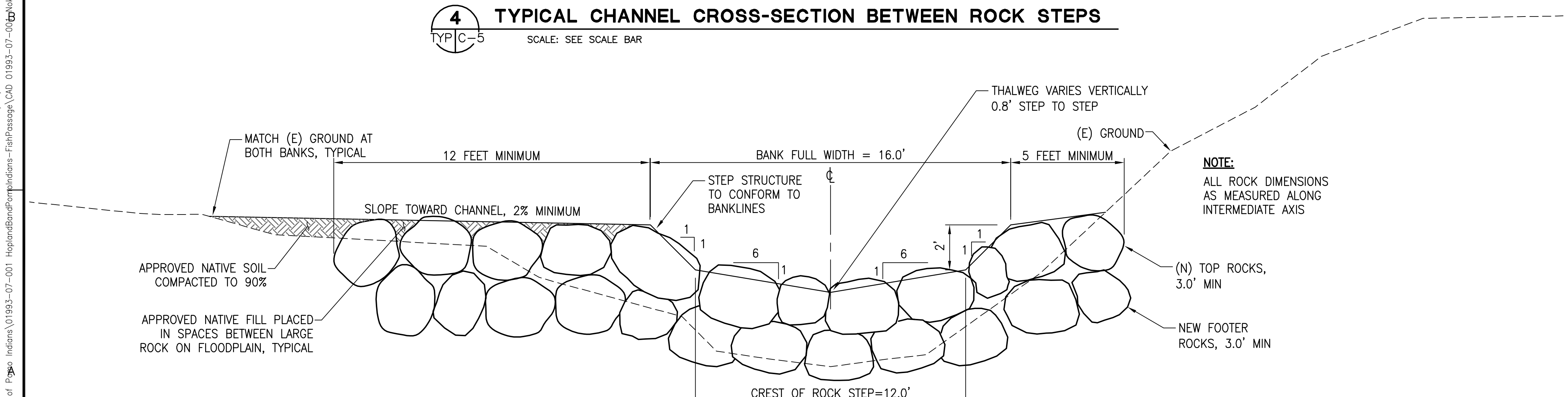
SCALE: SEE SCALE BAR



NOTE:
SEE ADDITIONAL NOTES ON SHEET C-4

4 TYP C-5 **TYPICAL CHANNEL CROSS-SECTION BETWEEN ROCK STEPS**

SCALE: SEE SCALE BAR



NOTE:
ALL ROCK DIMENSIONS
AS MEASURED ALONG
INTERMEDIATE AXIS

NOTE:
SEE ADDITIONAL NOTES ON SHEET C-4

5 TYP C-5 **TYPICAL ROCK STEP STRUCTURE CROSS-SECTION**

SCALE: SEE SCALE BAR

90% SUBMITTAL
NOT FOR CONSTRUCTION
NOVEMBER, 2009

NOTE:
LOCATION OF EXISTING UTILITIES & STRUCTURES ARE FROM THE BEST INFORMATION AVAILABLE. EXACT LOCATION AND COMPLETENESS ARE NOT GUARANTEED. CONTRACTOR SHALL NOTIFY UNDERGROUND SERVICES ALERT (800) 227-2600 A MIN. OF 48 HOURS PRIOR TO ANY EXCAVATION AND POTHOLE FOR EXACT LOCATION.

SYM.	DESCRIPTION	DATE	APPROVED
	REVISIONS		

WINZLER & KELLY
633 THIRD STREET
EUREKA, CA 95501-0417
PH (707) 443-8326
FAX (707) 444-8330

SUBCONSULTANT
Michael Love & Associates
PO Box 4477 Arcata, CA 95518 (707) 476-8938

DES TJ/AL
DRN TJ/SJD
SUPV SAA
CHK SAA/MLA

SEE SCALE BAR

SEAL

HOPLAND BAND OF POMO INDIANS
NISSA-KAH CREEK AT NOKOMIS ROAD
FISH PASSAGE IMPROVEMENT
CIVIL
TYPICAL CORSS-SECTIONS

JOB NUMBER 01993-07-001
SHEET 7 OF 7

C-5

0199307001-Nokomis_07-C5
P:\2005 & Beyond\01993 Hopland Band of Pomo Indians\01993-07-001 HoplandBandPomoIndians-FishPassage\CAD 01993-07-001_Nokomis.dwg
11/25/2009 3:17 PM

Appendix D
Opinion of Probable Construction and Project Cost

Nissa-Kah Creek Fish Passage Improvement Project at Nokomis Road Crossing

Engineers Opinion of Probable Construction and Project Cost - Based on November 2009 90% Design
Prepared for: Hopland Band of Pomo Indians

Item No	Item Description	Quantity	Unit	Unit Cost	Total
1	Mobilization and Demobilization	1	LS	$30,000	$30,000
2	Traffic Control	1	LS	$5,000	$5,000
3	Erosion, Sediment Control, and Creek Bypass	1	LS	$25,000	$25,000
4	Clearing, Grubbing, Demolition, and Disposal	1	LS	$30,000	$30,000
5	Excavation and Grading	1	LS	$40,000	$40,000
6	Native Backfill & Compaction	1	LS	$25,000	$25,000
7	Engineered Streambed Material for Roughened Channel	160	CY	$175	$27,951
8	Large Rock for Channel Rock Steps & Slope Protection	1,700	Ton	$150	$255,000
9	Outlet Sill	1	LS	$10,000	$10,000
10	Non-woven Geotextile Fabric for Rouhgened Channel	4,200	SF	$2	$8,400
11	Revegetation of Disturbed Areas	1	LS	$10,000	$10,000
12	Construction Staking	1	LS	$15,000	$15,000
				Subtotal:	$481,351
				Estimating Contingency @ 25%:	$120,338
				OPINION OF PROBABLE CONSTRUCTION COST (Rounded):	**$602,000**
				Final PS&E	$30,000
				Bidding Assistance	$5,000
				Construction Management	$75,000
				OPINION OF PROBABLE PROJECT COST (Rounded):	**$712,000**